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UNIVERSITY OF ALBERTA

Transit Ridership Analysis

by

Derrick W. Ploof

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled Transit Ridership Analysis submitted by Derrick W. Ploof in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE.

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Supervisor

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....

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Date April 23, 1990

To my Mother and Father

for providing love and support

no matter what the situation

and encouraging me

in everything I do

ABSTRACT

The main objective of this thesis has been to identify the characteristics of the people who use public transit in Edmonton, on both aggregate and disaggregate levels, using data from the 1988/89 Fare Survey in conjunction with other available Edmonton travel information.

Past transit studies involving ridership analysis have been conducted prevalently in terms of passengers. This thesis proposes that the analysis is better conducted in terms of users. A user is a person who uses public transit. That person does not become a passenger until physically boarding a transit vehicle. Therefore, all of the people who use transit may not be represented accurately by a passenger survey, because their normal frequency of use influences their chances of being included in the survey.

A model has been developed which transforms passenger data into user data. The key to the transformation are assumptions made about a users chance of inclusion in the survey based on their weekly frequency of use.

The model has been verified by comparing its estimates of total users, total rides, user weekly frequency-of-use distribution, and user non-cash fare payment methods against existing Edmonton Transit data.

The model has also been calibrated slightly using Edmonton Transit data. The Attitude and Awareness telephone survey was the most used database. This survey was conducted in conjunction with the 1988/89 Fare Survey, and because of

the nature of interviewing represented a sample of transit users.

The model has then been used to analyze various characteristics of transit users in Edmonton, including:

a. Total number.

b. Distribution within weekly frequency-of-use classes.

c. Disaggregated fare payment methods.

d. Distribution of use during different time periods.

e. Age distribution.

f. Origin and Destination purpose distributions.

g. Combinations of characteristics a - f.

The main objective of the thesis has been satisfied in that the above characteristics have or can be identified as a result of this research.

Acknowledgements

The author is deeply grateful to Professor Stan Teply for his never-ending guidance, advice, and support throughout this research.

In addition, the author wishes to thank various members of the Transportation Department of the City of Edmonton, in particular Greg Latham, Bob Strynadka, Ken Koropeski, and Bob MacDonald, for their help during this project.

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1.0 INTRODUCTION

A chapter containing some preliminary information is necessary before beginning discussion on the Transit User Analysis.

Among this information is the background work which led to this project. This work included a series of reports on transit passenger behaviour and mode choice, as well as the 1988/89 Fare Survey.

Another item is the distinction between a transit user and a transit passenger, which is vital for understanding all aspects of the study. A specific definition of the terms has been developed for this project.

Other topics included in this Chapter are the user characteristics which were analyzed and the study management process.

1.1 Background

Research has been conducted at the University of Alberta on transit passenger behaviour and mode choice using the available disaggregate data base. The results were summarized in three reports [1,2,3]. The first of these documents dealt with the application of marketing principles to public transportation planning and the design of transit services, the second provided an inventory of all work and documentation related to the 1983 Downtown Morning Commuter Survey, and the third report outlined the applications of that and similar data bases. A number of recommendations for future ridership analyses were made.

In the fall of 1988 and early spring of 1989, the City of Edmonton Transportation Department carried out a series of on-board ridership surveys. The survey dates were chosen such that changes in ridership characteristics caused by a fare increase in January 1989 could be identified. Although the prime objective of the surveys was to determine the methods of fare payment and the effects of fare changes, information on passengers, their trip characteristics and travel habits were also obtained. These surveys represented a statistically sufficient sample for further analytical work which the Transportation Department had considered for some time.

The main objective of the Transit Ridership Analysis has been to identify the characteristics of the people who use public transit in Edmonton, on both aggregate and disaggregate levels, using that data base in conjunction with other available Edmonton travel information. The following have been the transit user characteristics to be identified:

a. Total number.
b. Distribution within weekly frequency-of-use classes.
c. Disaggregated fare payment methods.
d. Distribution of use during different time periods.
e. Age distribution.
f. Origin and Destination distributions.
g. Combinations of characteristics a - f.

1.2 Distinction between Users and Passengers

The approach used in this research to analyze the 1988/89 Fare Survey data, i.e., examining user characteristics, has differed from the method used predominantly in past documented transit studies. A literature review conducted during the initial stages of this research has revealed that passenger characteristics are usually investigated. A definition of the difference between the terms has been developed for the study:

A user is a person who uses transit. A user does not become a passenger until he/she physically boards a transit vehicle.

The reason for the analysis of users instead of passengers is that in a passenger survey, frequent-use passengers are repeatedly overcounted, and infrequent-use passengers are often omitted. This results in one form of sample bias.

To remove this sample bias, the passenger data has been transformed into user data. The process has involved making assumptions about the level of undercounting and/or overcounting associated with each passenger, based on their stated weekly frequency of use. From these assumptions, passengers have then been transformed into the number of users they represent.

While this approach may be relatively new to public transit research, there is evidence of its use for marketing applications in other areas. For example, a study on the quality of Shopping Center sampling advocated the application of weighting factors, based on a sampled person's frequency of shopping trips, to account for the undercounting and overcounting bias described above [4].

1.3 User Characteristics Analyzed

The transit user characteristics analyzed in this study have been those thought most useful for future transit planning applications. Among these characteristics, fare payment methods of users have been analyzed to aid the design of pricing policies. More specifically, information obtained in the surveys has facilitated user-fare-payment analysis of various frequency-of-use categories, time periods, age groups, origin purposes, and destination purposes.

2.0 1988/89 FARE SURVEY

The Transit Ridership Analysis has utilized the 1988/89 Fare Survey data. This Chapter describes the data collection process of that survey.

In particular, the route selection process and sample size requirements determined the representativeness of the sample.

The questionnaire form, survey methodology, and survey dates and times formed the basis for collection of raw data.

Logic checking of questionnaires removed unreasonable responses from the database.

Other items in this chapter include the comparison of responses between the 1988 and 1989 portions of the Fare Survey, and the decision to use weekday data exclusively during the study.

2.1 Selection of Routes

The routes included in the Fare Survey were determined by City of Edmonton Transportation Management and were based on the following criteria [4]:

- means for the different fare types on a route being similar to the overall means of the fare types for a category of route. The route types surveyed were:

- Mainline
- Express
- Radial
- Crosstown
- University
- Feeder

- surveyed routes were not to be interlined with other routes (i.e., type of bus function, e.g., feeder, remained constant for the entire route).
- a mix of passengers was desired so that different geographical and socio-economic characteristics within Edmonton be represented. It was expected, however, that the older-user categories of passengers would be underrepresented by choosing the routes in this manner.
- routes operating for a low number of bus hours were selected to minimize survey cost.

2.2 Sample Size Requirement

An original sample size of 43,000 passengers was calculated as required to obtain a 90% level of confidence that the most popular passenger fare type in the sample (Adult Pass) was in error by at most 10%. Obtaining a sample of this size was not possible due to budget limitations. The final sample size was approximately 20,000 passengers which resulted in an error estimate of 12% for the most popular passenger fare type (Adult Pass) [5].

2.3 Questionnaire Form

The questionnaire distributed to the passengers contained information on the survey as well as the questions designed to obtain data [6]. The questionnaire, shown in Figure 1, was a single 4.5 X 8 inch card with printing on both sides. One side contained instructions and space for comments. The opposite side listed 8 questions about the passenger's trip:

- purpose at origin
- fare payment used
- number of transfers
- purpose at destination
- number of trips taken today
- number of trips taken in the past 7 days
- age of passenger
- sex of passenger

Bus Passenger Survey

The purpose of this survey is to gain information concerning your travel pattern to help us plan better bus services in Edmonton.

Please complete the other side of this card with details of the complete one-way trip you are making, (e.g. work to home, shopping to home or school to home). This bus ride may only be a portion of your complete one-way trip.

Please exit via the rear door. Hand completed card to surveyor at rear door as you exit.

Any questions about this survey? Please call 428-4364.

Comments: ______________________

Thank you for your cooperation and continued patronage.

Edmonton transit
Owned and operated by the City of Edmonton

Please fill in your answers as appropriate
Select only one box per question

34020

1 I am travelling from
☐ [illegible] ☐ [illegible] ☐ [illegible] ☐ [illegible] ☐ Shopping ☐ [illegible] ☐ [illegible] ☐ Other

1a The address (street and avenue only) or building name of the above is ______________________

2 What fare did you use to make this trip?

Cash	Ticket	Pass	
☐ [illegible]	☐ [illegible]	☐ [illegible]	☐ [illegible]
☐ Child	☐ Child	☐ [illegible]	☐ [illegible]
		☐ [illegible]	☐ Other
		☐ [illegible]	

3 How many transfers will you make as part of this trip?
☐ [illegible] ☐ [illegible] ☐ [illegible] ☐ [illegible] ☐ [illegible]

4 I am on my way to
☐ [illegible] ☐ [illegible] ☐ [illegible] ☐ [illegible] ☐ Shopping ☐ [illegible] ☐ [illegible] ☐ Other

4a The address (street or avenue only) or building name of the above is ______________________

Note: A one-way trip is a complete journey including transfers from one destination to another. Home to work would be one trip, returning home from work is a second trip.

5 How many one-way transit trips will you make today? _____

6 How many one-way transit trips have you made in the last seven days? (includes Evening, Saturday & Sunday as well as Weekday) _____

7 Age ☐ [illegible] ☐ [illegible] ☐ [illegible] ☐ [illegible] ☐ [illegible] ☐ [illegible] ☐ [illegible]

8 Sex ☐ Male ☐ Female

Thank you! Please hand to rear door surveyor when you exit

Figure 1. Questionnaire used in the 1988/89 Fare Survey

The number of trips taken today and number of trips taken in the past seven days questions provided blanks which the passenger had to fill in. For the remaining questions, passengers were given categories to choose from, and indicated their responses by checking off the appropriate box.

For the purpose at origin and purpose at destination questions, passengers were also asked to give the approximate address of their selection. Because the survey only included selected routes, no analysis has been performed during the study on geographic origin and destination patterns of users.

2.4 Survey Methodology

Two surveyors were used on each bus. A surveyor at the front entrance handed out questionnaires (in serial number order) and pencils to passengers boarding the bus. This surveyor also completed a survey control sheet: serial number of first remaining questionnaire after distribution to passengers, number of passengers refusing questionnaire, and actual arrival and departure times of the bus were recorded at each timing point along the route. The surveyor at the rear exit collected the completed questionnaires from the departing passengers. Both surveyors helped passengers complete the questionnaires when possible [6].

The surveys were conducted over eleven days in both November 1988 and March 1989. Each of the 9 routes was surveyed on a different weekday between 0600 and 2300h. Route 7 was also surveyed on a Saturday and Sunday to allow comparison with weekday passenger characteristics [5].

Each bus on one of the selected routes was surveyed for the entire day during that routes survey day. Table 1 lists the routes and the days that the surveys were conducted. Figure 2 shows the surveyed routes.

Dates of 1988 portion of the Fare Survey:

Date	Day	Route Surveyed
October 31	Monday	165
November 1	Tuesday	27
November 2	Wednesday	69
November 3	Thursday	7
November 4	Friday	116
November 5	Saturday	7
November 6	Sunday	7
November 7	Monday	67
November 8	Tuesday	74
November 9	Wednesday	77
November 10	Thursday	54

Dates of 1989 portion of the Fare Survey:

Date	Day	Route Surveyed
February 27	Monday	165
February 28	Tuesday	27
March 1	Wednesday	69
March 2	Thursday	7
March 3	Friday	116
March 4	Saturday	7
March 5	Sunday	7
March 6	Monday	67
March 7	Tuesday	74
March 8	Wednesday	77
March 9	Thursday	54

Table 1. Dates of 1988 and 1989 portions of the Fare Survey

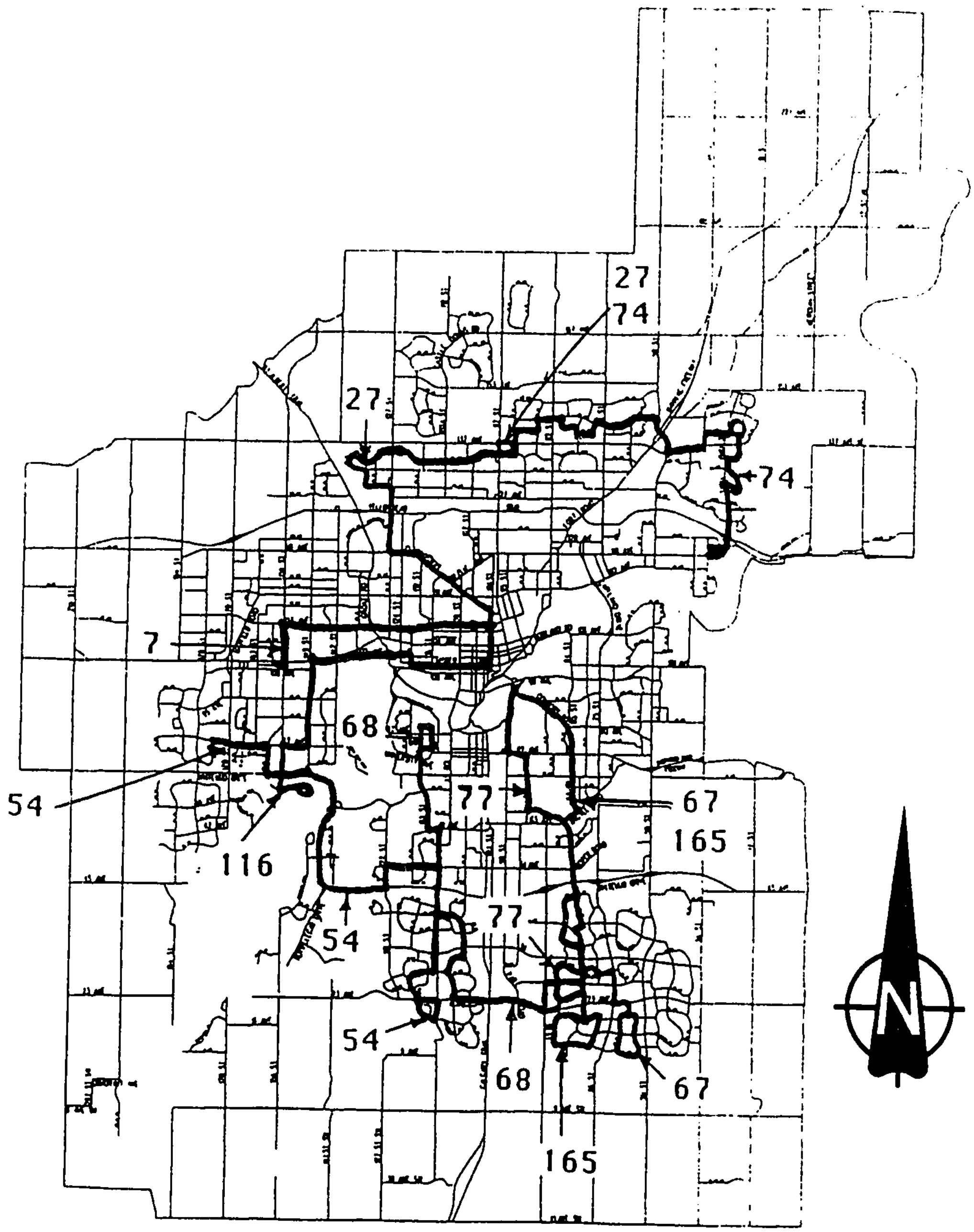


Figure 2. Routes included in 1988/89 Fare Survey

2.5 Logic Checking of Questionnaires

The sample data sets were inspected by City personnel for unreasonable responses [5]. Examples of unreasonable responses include:

a) Conflicting Responses, e.g., passengers who stated their age as 65+ years old and method of payment as Child Cash.

b) Limit Violation, e.g., passengers who stated that they had taken 20 one-way trips today.

Questionnaires with the above types of errors were either corrected or removed completely from the data set, based on the discretion of the reviewer.

It has been decided during the study to eliminate those observations whose response to "How many one-way trips have you made in the past 7 days?" had been coded to zero, because no response was given for this question. The conversion from passengers to users has been based on the response to this question, therefore observations of this type have had no use in the study.

Removing observations with a coding of zero for this question has also resulted in the deletion of some valid observations: those whose actual response to the "number of trips in the past 7 days" question was zero. It is not possible to determine the proportion of these observations.

However, they have been accounted for in the calibration of the transit user estimation model, which is discussed later. It is suggested that future surveys should utilize a different form of coding non-response questions, e.g. a negative number.

Stricter numerical constraints have been placed on the responses to the number of trips taken today and number of trips taken in the past 7 days questions. The limits have been set at 10 and 25, respectively.

2.6 Comparison of 1988 and 1989 Passenger Samples

The characteristics of the 1988 and 1989 passenger samples have been inspected at the beginning of the study. Response frequencies, expressed as percentages of passengers, have been compared for each survey question.

The match between the samples has been excellent. The largest difference has been a decrease in Adult Cash Fares from 25.8 % to 22.3 %. Correspondingly, Adult Pass use has increased from 29.2 % to 30.5 %, and Adult Ticket utilization has risen from 4.4 % to 6.3 %.

It has been decided that, because of the agreement between samples, the analysis of users would be undertaken on only the 1989 data. The only exception would be the comparison of user-fare-payment methods before and after the fare increase in January 1989.

2.7 Exclusive Use of Weekday Data

All routes were surveyed during a weekday, and weekend data was collected on only one mainline route. It has been agreed that, because of the lack of weekend data, the analysis focus exclusively on weekday users. This point is relevant in the development of the transit user estimation model.

3.0 TRANSIT USER ESTIMATION MODEL DEVELOPMENT

A logical development of the transit user estimation model is presented in this Chapter.

The basis for the model has been some initial assumptions. These assumptions have involved the daily and weekly distributions of transit passengers in Edmonton.

The concept of user representation factors has followed from these assumptions. These factors have been the basis for transforming passengers into users.

The passenger data has then been prepared for application of the user representation factors. This has involved the divison of passengers by type of route and weekly frequency of transit use.

Following the application of the user representation factors to convert the sample passengers into users, the sample has been extrapolated on a city-wide basis. Two methods of extrapolation have been developed during this study.

Scaling factors have also been applied to the user estimates to account for passengers who either refused to answer questionnaires or whose responses had been removed from the data. Two methods of developing scaling factors have been used in this study.

The transfer rate of passengers has been the final factor applied to the user estimate. This factor has been derived by Edmonton Transit based on various transit data.

All of the above components in combination form the initial transit user estimation models. From these models have come the initial estimates of the total number of transit users in Edmonton, along with the total yearly ridership.

3.1 Basic Model Assumptions

The conversion of passengers into users has been the foundation on which this study has been based. In order to develop a model which can transform passenger data into users, three basic assumptions have been made:

1. Ridership on the buses surveyed was relatively stable over the weekdays from Monday to Friday, i.e., the day of the survey would not bias the sample.

2. Some users were included in the survey samples more than once: specifically those with high bus use during the week.

3. Some infrequent transit users were not included in the sample because they did not travel on the day of the survey.

Assumption 1 has been supported by a February 1986 Transportation Department passenger-count survey conducted in the Goldbar neighborhood. The results of this survey, which extended over 5 consecutive weekdays, is shown in Figure 3.

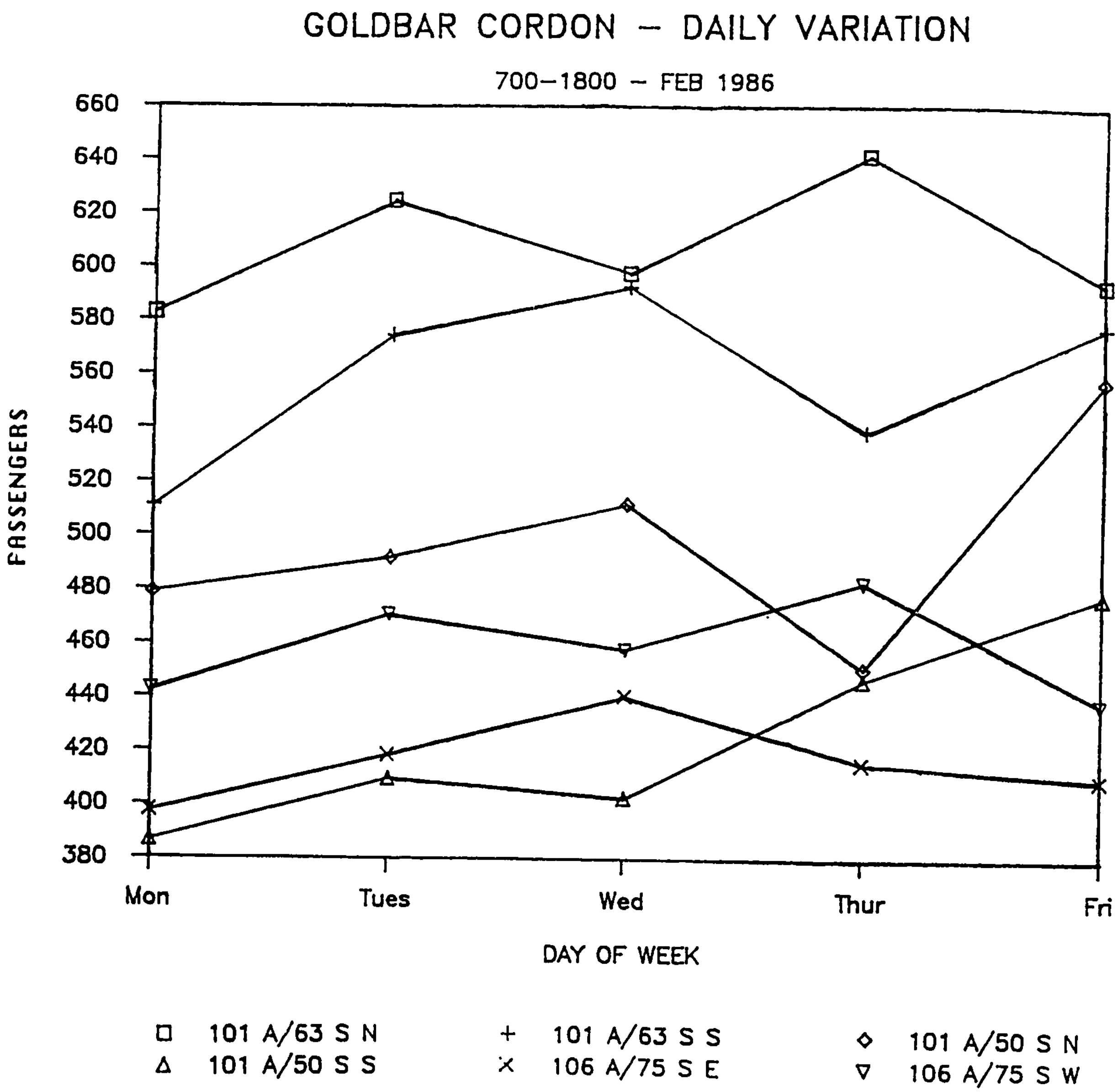


Figure 3. Results of passenger cordon count performed over 5 consecutive weekdays in February 1986

Assumptions 2 and 3 have been justified by the weekly-frequency-of-use distribution of users in the model. This distribution has agreed closely with the user distribution of the Attitude and Awareness Survey, as will be shown later.

3.2 Concept of User Representation Factors

Each passenger in the survey represents a certain number of transit users. The number of users he/she represents has been determined by his/her response to the question "How many one-way trips have you made in the past 7 days?". Since the passenger volumes are relatively stable over the weekdays (illustrated by Figure 3), the following assumption can be made: during a one-day survey, a passenger who stated that he uses transit once a week represents not only himself but also 4 other transit users with the same frequency of use. As a result, he represents 5 users in total and a factor of 5 has been used to transform this passenger into the appropriate number of users.

Passengers who utilize transit more frequently than once a week have a higher probability of being counted more than once during a one-day survey, and also a better chance of being included in the survey regardless of the day it occurs. Therefore a conversions factor less than 5 must be used.

3.21 Expansion Factors and Reduction Factors

The user representation factors have been a combination of expansion factors and reduction factors. Each passenger initially represented one user. This number has then been modified by the application of the expansion and reduction factors.

Expansion factors have been applied to passengers who have been assumed as not using transit every weekday during the week of the survey. This has accounted for other passengers, similar in usage frequency to some of those surveyed, who would have been included in the survey had it been done on one of the days they used transit that week. Expansion factors have been applied to light to mid-level transit use passengers. The boundary on the highest number of trips per week associated with expansion factors depended on the assumed number of trips taken per day (as discussed in Section 3.22).

Reduction factors accounted for the fact that, with the exception of a passenger who claims to have made only 1 one-way trip in the past 7 days, all passengers in the survey may have been surveyed more than once. High frequency-of-use passengers have likely been surveyed several times, and accordingly have been associated with the largest reduction factors. Reduction factors have been applied to any passenger whose stated weekly frequency of use exceeded 1 one-way trip.

Some passengers have been associated with both expansion and reduction factors due to their stated weekly frequency of use. Figure 4 lists examples which show how the expansion and reduction factors are calculated and the user representation factors which result (for the models of section 3.22.1 and 3.22.2).

Case 1: One trip per day assumed

Derivation of selected user representation factors

a) 3 trips/week => 1.67 users

Number of trips = 3						
Number of days on bus =3	eg	M	T	W	T	F
Number of days trips may occur = 5		1	1		1	

Expansion Factor: $\frac{\text{Number of days trips undercounted}}{\text{Number of days trips occur}} = \frac{2}{3}$

Number of days overcounted = 0 therefore Reduction Factor = 0

User representation factor = 1 + 2/3 - 0 = 1.67

b) 7 trips/week => 0.71 users

Number of trips = 7	eg	M	T	W	T	F
Number of days on bus = 5		1	1	2	1	2
Number of days on trips may occur = 5						

Number of days undercounted = 0 therefore Expansion Factor=0

Reduction Factor: $\frac{\text{Number of trips overcounted}}{\text{Number of trips total}} = \frac{2}{7}$

User representation factor = 1 + 0 - 2/7 = 0.71

Case 2: Two trips per day assumed

Derivation of selected user representation factors

a) 7 trips/week => 0.82 users

Number of trips = 7						
Number of days on bus = 4	eg	M	T	W	T	F
Number of days trips may occur = 5		1	2		2	2

Expansion Factor: $\frac{\text{Number of days trips undercounted}}{\text{Number of days trips occur}} = \frac{1}{4}$

Reduction Factor: $\frac{\text{Number of trips overcounted}}{\text{Number of trips total}} = \frac{3}{7}$

User representation factor = 1 + 1/4 - 3/7 = 0.82

Figure 4. Derivation of selected user representation factors

3.22 One vs Two Trip-Per-Day Models

Two extreme scenarios have been developed based on assumed transit traveller behaviour. They are in no way exhaustive but their aim has been to establish upper and lower boundaries of the number of transit users in Edmonton.

3.22.1 Case 1

Case 1 assumes that travellers take only one-way trips on the days they use transit. For instance, a person making 5 one-way trips per week has been assumed to travel once on each weekday. Similarly, a person taking 8 trips per week takes 2 trips on 3 weekdays and 1 trip on the other two days. An example of this case would be a person who is an auto passenger to work in the morning and uses transit for the return trip home.

3.22.2 Case 2

The second scenario has assumed that people make the trip to and from the destination on transit, i.e., they usually take two one-way trips when they use transit. A person making 7 one-way trips per week makes 2 trips per day for three of the weekdays, and 1 trip on one of the other two days. The most frequent example of this case is a person who uses transit to travel to and from work each day.

3.23 User Representation Factors Used in Model

A complete set of user representation factors has been developed for the scenarios described in sections 3.22.1 and 3.22.2. Table 2 lists the user representation factors, each associated with a particular weekly-frequency-of-use category, for each model.

Case 1 User representation factors: 1 trip per day assumed

Passenger Type (trips/week)	Number of users represented	Passenger Type (trips/week)	Number of users represented
1	5.00	13	0.38
2	2.50	14	0.36
3	1.67	15	0.33
4	1.25	16	0.31
5	1.00	17	0.29
6	0.83	18	0.28
7	0.71	19	0.26
8	0.63	20	0.25
9	0.56	21	0.24
10	0.50	22	0.23
11	0.45	23	0.22
12	0.42	24	0.21
		25	0.20

Case 2 User representation factors: 2 trips per day assumed

Passenger Type (trips/week)	Number of users represented	Passenger Type (trips/week)	Number of users represented
1	5.00	13	0.38
2	4.50	14	0.36
3	2.17	15	0.33
4	2.00	16	0.31
5	1.27	17	0.29
6	1.17	18	0.28
7	0.82	19	0.26
8	0.75	20	0.25
9	0.56	21	0.24
10	0.50	22	0.23
11	0.45	23	0.22
12	0.42	24	0.21
		25	0.20

Table 2. User Representation Factors for One-trip-per-day and Two-trip-per-day models

3.3 Application of User Representation Factors to Passenger Data

Passengers included in the sample have been converted into users after their classification by weekly frequency of use and route on which they were surveyed. The number of users a passenger represents has been directly related to the number of one-way trips he claims to have taken in the past 7 days. The reason for the route classification has been to allow an extrapolation on a city-wide basis.

For three of the route types surveyed, Mainline, Radial, and Express, two routes for each route type were investigated. This required that an average be calculated for the number of passengers in each category of weekly frequency of use, before calculating the number of users for these route types.

3.4 Development of City-Wide Model

After converting the passenger sample into users, it has been possible to extrapolate the sample across the city. Two methods have been used in this analysis.

3.4.1 Route Extrapolation Method

The initial simple method has expanded the users on a route type in proportion to the number of routes of that type which operate in the city. For example, because eleven University routes are operated during weekdays, the user estimate for the surveyed University route has been multiplied by 11 to get the total number of users on these routes.

3.4.2 Passenger Extrapolation Method

Edmonton Transit has suggested an alternative approach for user extrapolation. Users have been expanded in proportion to the number of boardings on the surveyed route to the total number of boardings for that route type. For the University routes, Edmonton Transit Operator Counts indicate 35,812 boardings. The surveyed University route had 3,347 boardings. The user estimate for University routes has been multiplied by 10.7 (35,812/3,347) to get the total University route user estimate.

As shown in Chapter 6, the second method has been judged more accurate for estimating users. The first method provides a reasonable alternative, however, especially when operator counts are not available.

3.5 Scaling Factors

Scaling factors have been used in the survey to account for those passengers who were on the surveyed buses, but either refused to answer the questionnaires, or whose responses have been removed from the sample because of reasons explained in Section 2.5. Two scaling factor methods have been developed for the analysis, both related to the approach used for city-wide extrapolation.

The first method, related to the route extrapolation technique, has involved development of a single scaling factor for all routes. The ratio of the total number of boardings during the survey (24,856) to the number of sample questionnaires used (15,977) has resulted in a scaling factor of 1.56.

The second method, associated with the passenger extrapolation technique, has developed scaling factors for each route type. The factors have been based on the ratio of the total boardings for the surveyed route to the number of questionnaires used from that route. For instance, the surveyed University route had 3347 boardings; 2082 questionnaires were used. A scaling factor of 1.61 has been associated with this route type.

3.6 Transfer Rate Used

A transfer rate of 1.6 has been developed by Edmonton Transit [5] based on the 1988/89 Fare Survey. It has been agreed to use this factor when estimating users based on the Fare Survey sample.

3.7 Initial User Estimation Model

The transit user estimation model has combined the Fare Survey passenger data with user representation, city-wide extrapolation, scaling, and transfer rate factors. Two versions of the model have been developed, based on the method of extrapolating the results city-wide. Within each model, two scenarios exist depending on the assumed daily distribution of user trips.

A simplified flowchart of the process in which passenger observations are combined with the model components to produce user estimates is shown in Figure 4.

The models, shown in Tables 3-6, have generated estimates of the number of weekday transit users in Edmonton. A spreadsheet has been used for initial development of the models; the components have been applied directly to the cross-tabulated data set (organized by route and number of trips in past 7 days) in later applications.

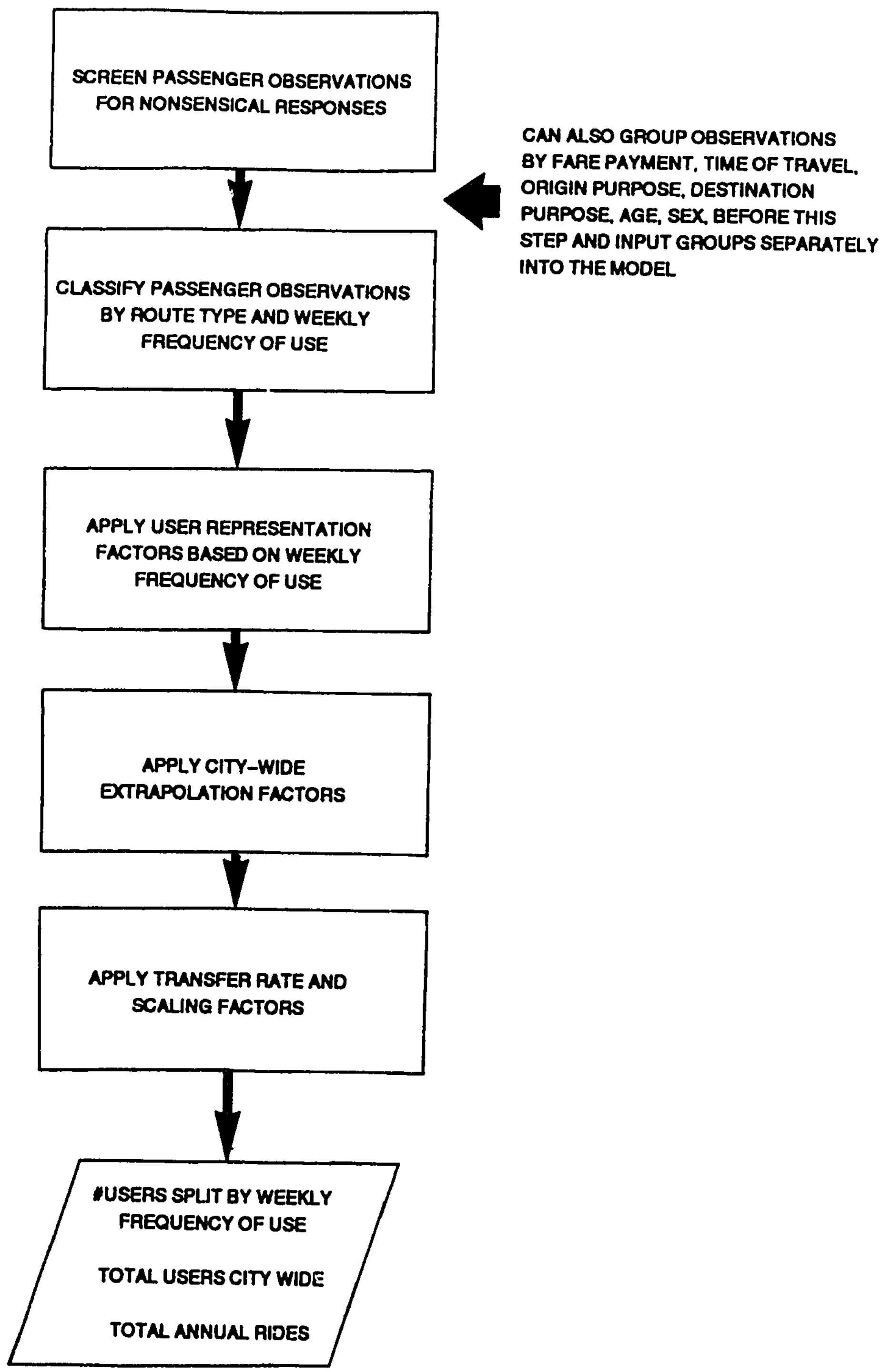


Figure 4. Process of passenger data transformation to produce estimates of user characteristics

Route Extrapolation Model - 1 trip assumption weekday model										Numbers in bold converted to users							Weekday Users						
trips per week						Passenger counts								users per passenger		mainline	radial	express	crosstown	university	feeder	Number of users	% users
	7	67	ave	27	77	ave	116	165	ave	54	68	74											
1	30	25	27.5	22	18	20	7	17	12	27	22	46		5		137.50	100.00	60.00	135.00	110.00	230.00	14565	10.69
2	80	56	68	41	61	51	23	43	33	52	56	98		2.5		170.00	127.50	82.50	130.00	140.00	245.00	16713	12.26
3	75	43	59	28	40	34	6	23	14.5	35	61	56		1.67		98.53	56.78	24.22	58.45	101.87	93.52	7383	5.42
4	145	79	112	70	67	68.5	17	46	31.5	87	159	140		1.25		140.00	85.63	39.38	108.75	198.75	175.00	12871	9.44
5	157	151	154	110	102	106	49	92	70.5	128	189	197		1		154.00	106.00	70.50	128.00	189.00	197.00	14745	10.82
6	112	92	102	86	94	90	15	58	36.5	92	170	125		0.83		84.66	74.70	30.30	76.36	141.10	103.75	8546	6.27
7	101	74	87.5	40	53	46.5	27	45	36	68	94	108		0.71		62.13	33.02	25.56	48.28	66.74	76.68	5492	4.03
8	122	63	92.5	57	80	68.5	37	53	45	89	98	113		0.83		58.28	43.16	28.35	56.07	61.74	71.19	5481	4.02
9	39	18	28.5	16	27	21.5	19	11	15	33	24	35		0.56		15.96	12.04	8.40	18.48	13.44	19.60	1498	1.10
10	404	359	382	203	368	286	175	330	253	376	534	632		0.5		190.75	142.75	126.25	188.00	267.00	316.00	22211	16.30
11	26	24	25	18	20	19	14	11	12.5	23	33	40		0.45		11.25	8.55	5.63	10.35	14.85	18.00	1244	0.91
12	146	155	151	65	118	91.5	31	66	48.5	121	137	255		0.42		63.21	38.43	20.37	50.82	57.54	107.10	6491	4.76
13	17	17	17	12	14	13	3	8	5.5	21	21	40		0.38		6.46	4.94	2.09	7.98	7.98	15.20	869	0.64
14	257	198	228	108	227	168	48	84	66	219	185	405		0.36		81.90	60.30	23.76	78.84	66.60	145.80	8786	6.45
15	58	36	47	33	39	36	12	25	18.5	51	48	98		0.33		15.51	11.88	6.11	16.83	15.84	32.34	1912	1.40
16	89	46	67.5	26	57	41.5	12	22	17	41	57	100		0.31		20.93	12.87	5.27	12.71	17.67	31.00	1933	1.42
17	25	17	21	5	18	11.5	3	3	3	13	23	41		0.29		6.09	3.34	0.87	3.77	6.67	11.89	660	0.48
18	40	29	34.5	25	25	25	4	12	8	37	36	60		0.28		9.66	7.00	2.24	10.36	10.08	16.80	1040	0.76
19	10	7	8.5	5	10	7.5	1	0	0.5	1	4	12		0.26		2.21	1.95	0.13	0.26	1.04	3.12	188	0.14
20	124	56	90	48	62	55	6	30	18	70	81	148		0.25		22.50	13.75	4.50	17.50	20.25	37.00	2218	1.63
21	26	9	17.5	11	19	15	2	7	4.5	11	25	41		0.24		4.20	3.60	1.08	2.64	6.00	9.84	562	0.41
22	16	9	12.5	6	6	6	0	1	0.5	8	4	11		0.23		2.88	1.38	0.12	1.84	0.92	2.53	171	0.13
23	1	4	2.5	1	6	3.5	0	0	0	2	5	9		0.22		0.55	0.77	0.00	0.44	1.10	1.98	105	0.08
24	22	5	13.5	5	17	11	1	1	1	12	11	27		0.21		2.84	2.31	0.21	2.52	2.31	5.67	318	0.23
25	15	16	15.5	9	9	9	0	3	1.5	9	5	28		0.2		3.10	1.80	0.30	1.80	1.00	5.60	293	0.21
	2137	1588	1863	1050	1557	1304	512	991	751.5	1626	2082	2865			#users	1365.075	954.425	568.11	1186.05	1519.49	1971.61	136292	100.00
														x # routes		12	19	18	5	11	35		
																16380.90	18134.08	10225.98	5830.25	16714.39	69006.35		
																136292	Weekday users citywide						

Table 3. Route-extrapolation model: 1 trip per day

Route Extrapolation Model - 2 trip assumption weekday model										Numbers in bold converted to users								Weekday Users					
trips per week						Passenger counts								users per passenger		mainline	radial	express	crosstown	university	feeder	Number of users	% users
	7	67	ave	27	77	ave	116	165	ave	54	68	74											
1	30	25	27.5	22	18	20	7	17	12	27	22	46		5		137.50	100.00	60.00	135.00	110.00	230.00	14565	8.62
2	80	56	68	41	61	51	23	43	33	52	56	98		4.5		306.00	229.50	148.50	234.00	252.00	441.00	30083	17.80
3	75	43	59	28	40	34	6	23	14.5	35	61	56		2.17		128.03	73.78	31.47	75.95	132.37	121.52	9594	5.68
4	145	79	112	70	67	68.5	17	46	31.5	87	159	140		2		224.00	137.00	63.00	174.00	318.00	280.00	20593	12.19
5	157	151	154	110	102	106	49	92	70.5	128	189	197		1.27		195.58	134.62	89.54	162.56	240.03	250.19	18726	11.08
6	112	92	102	86	94	90	15	58	36.5	92	170	125		1.17		119.34	105.30	42.71	107.64	198.90	146.25	12046	7.13
7	101	74	87.5	40	53	46.5	27	45	36	68	94	108		0.82		71.75	38.13	29.52	55.76	77.08	88.56	6343	3.75
8	122	63	92.5	57	80	68.5	37	53	45	89	98	113		0.75		69.38	51.38	33.75	66.75	73.50	84.75	6525	3.86
9	39	18	28.5	16	27	21.5	19	11	15	33	24	35		0.56		15.96	12.04	8.40	18.48	13.44	19.60	1498	0.89
10	404	359	382	203	388	286	175	330	253	376	534	632		0.5		190.75	142.75	128.25	188.00	267.00	316.00	22211	13.14
11	26	24	25	18	20	19	14	11	12.5	23	33	40		0.45		11.25	8.55	5.63	10.35	14.85	18.00	1244	0.74
12	146	155	151	65	118	91.5	31	66	48.5	121	137	255		0.42		63.21	38.43	20.37	50.82	57.54	107.10	6491	3.84
13	17	17	17	12	14	13	3	8	5.5	21	21	40		0.38		8.46	4.94	2.09	7.98	7.98	15.20	869	0.51
14	257	198	228	108	227	168	48	84	66	219	185	405		0.36		81.90	60.30	23.76	78.84	66.60	145.80	8786	5.20
15	58	36	47	33	39	36	12	25	18.5	51	48	98		0.33		15.51	11.88	6.11	16.83	15.84	32.34	1912	1.13
16	89	46	67.5	26	57	41.5	12	22	17	41	57	100		0.31		20.93	12.87	5.27	12.71	17.87	31.00	1933	1.14
17	25	17	21	5	18	11.5	3	3	3	13	23	41		0.29		6.09	3.34	0.87	3.77	6.67	11.89	660	0.39
18	40	29	34.5	25	25	25	4	12	8	37	36	60		0.28		9.66	7.00	2.24	10.36	10.08	16.80	1040	0.62
19	10	7	8.5	5	10	7.5	1	0	0.5	1	4	12		0.26		2.21	1.95	0.13	0.26	1.04	3.12	186	0.11
20	124	56	90	48	62	55	6	30	18	70	81	148		0.25		22.50	13.75	4.50	17.50	20.25	37.00	2218	1.31
21	26	9	17.5	11	19	15	2	7	4.5	11	25	41		0.24		4.20	3.60	1.08	2.64	6.00	9.84	562	0.33
22	16	9	12.5	6	6	6	0	1	0.5	8	4	11		0.23		2.88	1.38	0.12	1.84	0.92	2.53	171	0.10
23	1	4	2.5	1	6	3.5	0	0	0	2	5	9		0.22		0.55	0.77	0.00	0.44	1.10	1.98	105	0.06
24	22	5	13.5	5	17	11	1	1	1	12	11	27		0.21		2.84	2.31	0.21	2.52	2.31	5.67	318	0.19
25	15	16	15.5	9	9	9	0	3	1.5	9	[illegible]	28		0.2		3.10	1.80	0.30	1.80	1.00	5.60	293	0.17
	2137	1588	1863	1050	1557	1304	512	991	751.5	1626	2082	2865			#users	1711.56	1197.355	705.79	1436.8	1912.17	2421.74	168971	100.00
														x # routes		12	19	18	5	11	35		
																20538.72	22749.75	12704.22	7184.00	21033.87	84760.90		
																168971	Weekday users citywide						

Table 4. Route-extrapolation model: 2 trips per day

Passenger Extrapolation Model - 1 trip assumption model									Numbers in bold converted to users			
						Passenger counts						
trips per week	7	67	ave	27	77	ave	116	165	ave	54	68	74
1	30	25	27.5	22	18	20	7	17	12	27	22	46
2	80	56	68	41	61	51	23	43	33	52	56	98
3	75	43	59	28	40	34	6	23	14.5	35	61	56
4	145	79	112	70	67	68.5	17	46	31.5	87	159	140
5	157	151	154	110	102	106	49	92	70.5	123	189	197
6	112	92	102	86	94	90	15	58	36.5	92	170	125
7	101	74	87.5	40	53	46.5	27	45	36	68	94	108
8	122	63	92.5	57	80	68.5	37	53	45	89	98	113
9	39	18	28.5	16	27	21.5	19	11	15	33	24	35
10	404	359	382	203	368	286	175	330	253	376	534	632
11	26	24	25	18	20	19	14	11	12.5	23	33	40
12	146	155	151	65	118	91.5	31	66	48.5	121	137	255
13	17	17	17	12	14	13	3	8	5.5	21	21	40
14	257	198	228	108	227	168	48	84	66	219	185	405
15	58	36	47	33	39	36	12	25	18.5	51	48	98
16	89	46	67.5	26	57	41.5	12	22	17	41	57	100
17	25	17	21	5	18	11.5	3	3	3	13	23	41
18	40	29	34.5	25	25	25	4	12	8	37	36	60
19	10	7	8.5	5	10	7.5	1	0	0.5	1	4	12
20	124	56	90	48	62	55	6	30	18	70	81	148
21	26	9	17.5	11	19	15	2	7	4.5	11	25	41
22	16	9	12.5	6	6	6	0	1	0.5	8	4	11
23	1	4	2.5	1	6	3.5	0	0	0	2	5	9
24	22	5	13.5	5	17	11	1	1	1	12	11	27
25	15	16	15.5	9	9	9	0	3	1.5	9	5	28
	2137	1588	1863	1050	1557	1304	512	991	751.5	1626	2032	2865

trips per week	users per passenger		Users: mainline	radial	express	crosstown	university	feeder	Number of users	% users
1	5		137.50	100.00	60.00	135.00	110.00	230.00	11272	10.25
2	2.5		170.00	127.50	82.50	130.00	140.00	245.00	13383	12.18
3	1.67		98.53	56.78	24.22	58.45	101.87	93.52	6523	5.93
4	1.25		140.00	85.63	39.38	108.75	198.75	175.00	10769	9.80
5	1		154.00	106.00	70.50	128.00	189.00	197.00	12290	11.18
6	0.83		84.66	74.70	30.30	76.36	141.10	103.75	7449	6.78
7	0.71		62.13	33.02	25.56	48.28	66.74	76.68	4516	4.11
8	0.63		58.28	43.16	28.35	56.07	61.74	71.19	4666	4.25
9	0.56		15.96	12.04	8.40	18.48	13.44	19.60	1282	1.17
10	0.5		190.75	142.75	126.25	188.00	267.00	316.00	17483	15.91
11	0.45		11.25	8.55	5.63	10.35	14.85	18.00	987	0.90
12	0.42		63.21	38.43	20.37	50.82	57.54	107.10	4900	4.46
13	0.38		6.46	4.94	2.09	7.98	7.98	15.20	624	0.57
14	0.36		81.90	60.30	23.76	78.84	66.60	145.80	6685	6.08
15	0.33		15.51	11.88	6.11	16.83	15.84	32.34	1406	1.28
16	0.31		20.93	12.87	5.27	12.71	17.67	31.00	1502	1.37
17	0.29		6.09	3.34	0.87	3.77	6.67	11.89	471	0.43
18	0.28		9.66	7.00	2.24	10.36	10.08	16.80	807	0.73
19	0.26		2.21	1.95	0.13	0.26	1.04	3.12	148	0.13
20	0.25		22.50	13.75	4.50	17.50	20.25	37.00	1690	1.54
21	0.24		4.20	3.60	1.08	2.64	6.00	9.84	398	0.36
22	0.23		2.88	1.38	0.12	1.84	0.92	2.53	153	0.14
23	0.22		0.55	0.77	0.00	0.44	1.10	1.98	70	0.06
24	0.21		2.84	2.31	0.21	2.52	2.31	5.67	235	0.21
25	0.2		3.10	1.80	0.30	1.80	1.00	5.60	208	0.19
		#users	1365.075	954.425	568.11	1166.05	1519.49	1971.61	109919	100.00
	x rep routes		18.17	19.28	16.81	8.56	10.7	10.47		
	x scaling factor		1.86	2.04	1.21	1.61	1.61	1.86		
			46134.35	37538.68	11555.41	16070.03	26176.25	38395.53		
			175870	Weekday users citywide						
			allow factor of 1.6 for transfers							
			109919	Weekday users citywide						

Table 5. Passenger-extrapolation model: 1 trip per day

Passenger Extrapolation Model - 2 trip assumption model									Numbers in bold converted to users							Users					
trips per week	Passenger counts												users per passenger	mainline	radial	express	crosstown	university	feeder	Number of users	% users
	7	67	ave	27	77	ave	116	165	ave	54	68	74									
1	30	25	27.5	22	18	20	7	17	12	27	22	46	5	137.50	100.00	60.00	135.00	110.00	230.00	11272	8.23
2	80	56	68	41	61	51	23	43	33	52	56	98	4.5	306.00	229.50	148.50	234.00	252.00	441.00	24089	17.58
3	75	43	59	28	40	34	6	23	14.5	35	61	56	2.17	128.03	73.78	31.47	75.95	132.37	121.52	8476	6.19
4	145	79	112	70	67	68.5	17	46	31.5	87	159	140	2	224.00	137.00	63.00	174.00	318.00	280.00	17231	12.58
5	157	151	154	110	102	106	49	92	70.5	128	189	197	1.27	195.58	134.62	89.54	162.56	240.03	250.19	15608	11.39
6	112	92	102	86	94	90	15	58	36.5	92	170	125	1.17	119.34	105.30	42.71	107.64	198.90	146.25	10501	7.66
7	101	74	87.5	40	53	46.5	27	45	36	68	94	108	0.82	71.75	38.13	29.52	55.76	77.08	88.56	5216	3.81
8	122	63	92.5	57	80	68.5	37	53	45	89	98	113	0.75	69.38	51.38	33.75	66.75	73.50	84.75	5555	4.05
9	39	18	28.5	16	27	21.5	19	11	15	33	24	35	0.56	15.96	12.04	8.40	18.48	13.44	19.60	1282	0.94
10	404	359	382	203	368	286	175	330	253	376	534	632	0.5	190.75	142.75	126.25	188.00	267.00	316.00	17483	12.76
11	26	24	25	18	20	19	14	11	12.5	23	33	40	0.45	11.25	8.55	5.63	10.35	14.85	18.00	987	0.72
12	146	155	151	65	118	91.5	31	66	48.5	121	137	255	0.42	63.21	38.43	20.37	50.82	57.54	107.10	4900	3.58
13	17	17	17	12	14	13	3	8	5.5	21	21	40	0.38	6.46	4.94	2.09	7.98	7.98	15.20	624	0.46
14	257	198	228	108	227	168	48	84	66	219	185	405	0.36	81.90	60.30	23.76	78.84	66.60	145.80	6685	4.88
15	58	36	47	33	39	36	12	25	18.5	51	48	98	0.33	15.51	11.88	6.11	16.83	15.84	32.34	1406	1.03
16	89	46	67.5	26	57	41.5	12	22	17	41	57	100	0.31	20.93	12.87	5.27	12.71	17.67	31.00	1502	1.10
17	25	17	21	5	18	11.5	3	3	3	13	23	41	0.29	6.09	3.34	0.87	3.77	6.67	11.89	471	0.34
18	40	29	34.5	25	25	25	4	12	8	37	36	60	0.28	9.66	7.00	2.24	10.36	10.08	16.80	807	0.59
19	10	7	8.5	5	10	7.5	1	0	0.5	1	4	12	0.26	2.21	1.95	0.13	0.26	1.04	3.12	148	0.11
20	124	56	90	48	62	55	6	30	18	70	81	148	0.25	22.50	13.75	4.50	17.50	20.25	37.00	1690	1.23
21	26	9	17.5	11	19	15	2	7	4.5	11	25	41	0.24	4.20	3.60	1.08	2.64	6.00	9.84	398	0.29
22	16	9	12.5	6	6	6	0	1	0.5	8	4	11	0.23	2.88	1.38	0.12	1.84	0.92	2.53	153	0.11
23	1	4	2.5	1	6	3.5	0	0	0	2	5	9	0.22	0.55	0.77	0.00	0.44	1.10	1.98	70	0.05
24	22	5	13.5	5	17	11	1	1	1	12	11	27	0.21	2.84	2.31	0.21	2.52	2.31	5.67	235	0.17
25	15	16	15.5	9	9	9	0	3	1.5	9	5	28	0.2	3.10	1.80	0.30	1.80	1.00	5.60	208	0.15
	2137	1588	1863	1050	1557	1304	512	991	751.5	1626	2082	2865	#users	1711.56	1197.355	705.79	1436.8	1912.17	2421.74	136998	100.00
													x rep. routes	18.17	19.28	16.81	8.56	10.7	10.47		
													x scaling factor	1.88	2.04	1.21	1.61	1.61	1.86		
														57844.22	47093.41	14355.84	19801.40	32940.95	47161.45		
														219197	Weekday users citywide						
														allow factor of 1.6 for transfers							
														136998	Weekday users citywide						

Table 6. Passenger-extrapolation model: 2 trips per day

4.0 MODEL VERIFICATION

Verification of the Transit User Estimation model has been required prior to the estimation of user segments.

The predictive abilities of the models developed in Chapter 3 have been tested against existing Edmonton Transit data. The total users, user weekly frequency-of-use distributions, and total rides estimated by the models have been compared to values obtained from the Attitude and Awareness Survey. Total ride estimates have also been compared to a benchmark value obtained from Edmonton Transit Operator Counts.

4.1 Total User Estimates

The total user estimate has combined the weekday, weekend, LRT and Industrial user segments. Assumptions have been required for LRT and Industrial user estimation as these routes were not included in the Fare Survey.

The development of total user estimates for each model is described in this section. The route extrapolation model is developed first. The passenger extrapolation model which follows employs slightly different estimation techniques.

The total user calculation of the route extrapolation model has differed from the passenger extrapolation model in the following ways:

(a) Extrapolation of users city-wide

(b) Scaling factors used

(c) Estimation of weekend users

(d) Estimation of LRT and Industrial users

Differences (a) and (b) are discussed in Sections 3.4 and 3.5.

A separate model has been developed for estimation of weekend users in the route extrapolation model. The form has been similar to the weekday model, with the following exceptions: the trips have been assumed taken on the weekend only, and the weekend passenger data obtained from a single mainline route has been representative of all weekend routes.

The passenger extrapolation model has estimated weekend users, based on the number of weekday users, in proportion to the ratio of Saturday boardings and Sunday boardings to weekday boardings. Edmonton Transit estimates, from operator counts, that Saturdays have 40%, and Sundays 20%, of the boardings of a typical weekday.

20,000 users have been estimated for LRT and Industrial routes in the route extrapolation model. This number has been approximated due to a lack of information during the study.

LRT and Industrial routes have been treated as mainline and feeder routes, respectively, for the passenger extrapolation model. The passenger boardings on the LRT and

Industrial routes have been compared to total boardings on the mainline and feeder routes, and users have been estimated proportionately. This has resulted in estimates of 17,208 users, from the one-trip scenario, and 21,549 users, for the two-trip scenario within the Passenger extrapolation model. These numbers fall within the range of the previous estimate of 20,000 LRT and Industrial route users from the route extrapolation model.

Figures 5-8 show the development of the total user estimates for each of the models two scenarios. The resulting estimates have been:

Model	Scenario	Total User Estimate
Route extrapolation	One-trip assumption	173,750
Route extrapolation	Two-trip assumption	208,537
Pass. extrapolation	One-trip assumption	140,317
Pass. extrapolation	Two-trip assumption	174,986

Route Extrapolation Model total user estimate:
(one trip assumption)

a) initial summation:

Weekday users	136,292
Weekend users	29,093
	165,385

b) Apply scaling factor => 1.56 X 165,385 = 258,001

c) Add LRT and Industrial users => 258,001 + 20,000 = 278,001

d) Apply transfer rate => 278,001/1.6 = **173,750 users**

Figure 5. Route-extrapolation model (one-trip-per-day assumption) total user estimate

Route Extrapolation Model total user estimate:
(two trips assumption)

a) initial summation:

Weekday users	168,971
Weekend users	32,093
	201,064

b) Apply scaling factor => 1.56 X 201,064 = 313,660

c) Add LRT and Industrial users => 313,660 + 20,000 = 333,660

d) Apply transfer rate => 333,660/1.6 = **208,537 users**

Figure 6. Route-extrapolation model (two-trips-per-day assumption) total user estimate

Passenger Extrapolation Model total user estimate:
(one trip assumption)

a) LRT estimate (treating as a mainline route)

LRT => 22,000 boardings

Mainlines: 62,889 boardings => 46,109/1.6 = 28,818 users
(Weekday)

22,000/62,889 X 28,818 =	10,081 users
Saturday (40% of weekday)	4,032 users
Sunday (20% of weekday)	2,016 users
	16,130 users

b) Industrial estimate (treating as a feeder route)

Industrial => 2,506 boardings

Feeders: 55,775 boardings => 38,372/1.6 = 23,983 users
(Weekday)

2,506/55,775 X 23,983 users =	1,078 users

c) Weekend users

Weekday => 109,919 users

Saturday (40% of a weekday):	109,919/5 X 0.40 =	8,793 users
Sunday (20% of a weekday):	109,919/5 X 0.20 =	4,397 users
		13,190 users

d) Summation

Weekday	109,919 users
Weekend	13,191 users
LRT	16,130 users
Industrial routes	1,078 users
	140,317 users

Figure 7. Passenger-extrapolation model (one-trip-per-day assumption) total user estimate

Passenger Extrapolation Model total user estimate:
(two trips assumption)

a) LRT estimate (treating as a mainline route)

LRT => 22,000 boardings

Mainlines: 62,889 boardings => 57,816/1.6 = 36,135 users
(Weekday)

22,000/62,889 X 36,135 =	12,641 users
Saturday (40% of weekday)	5,056 users
Sunday (20% of weekday)	2,528 users
	20,225 users

b) Industrial estimate (treating as a feeder route)

Industrial => 2,506 boardings

Feeders: 55,775 boardings => 47,136/1.6 = 29,460 users
(Weekday)

2,506/55,775 X 29,460 users = 1,323 users

c) Weekend users

Weekday => 136,998 users

Saturday	(40% of a weekday):	136,998/5 X 0.40 = 10,960 users
Sunday	(20% of a weekday):	136,998/5 X 0.20 = 5,480 users
		16,440 users

d) Summation

Weekday	136,998 users
Weekend	16,440 users
LRT	20,225 users
Industrial routes	1,323 users
	174,986 users

Figure 8. Passenger-extrapolation model (two-trips-per-day assumption) total user estimate

4.11 Attitude and Awareness Survey Total Transit User Estimate

The results of the total transit user estimates in Section 4.1 have been tested against the Attitude and Awareness Survey. That survey has determined that 32% of the adult population (18 years of age or older) in Edmonton (142,000 people) uses transit [7].

Expansion of the Attitude and Awareness results to include users in the 6-17 age category has been required for comparison. The method used has incorporated the Fare Survey sample percentage of users in this age category into the Attitude and Awareness user estimate. This has required an assumption of similarity between the two samples (shown to be valid later). In addition, Fare Survey frequency-of-use distribution patterns have been compared between 6-17 and 18+ age categories. The match of distributions, shown in Figure 9, has validated expansion of the Attitude and Awareness sample to include 6-17 year-old users through the use of the Fare Survey user percentage for this age category.

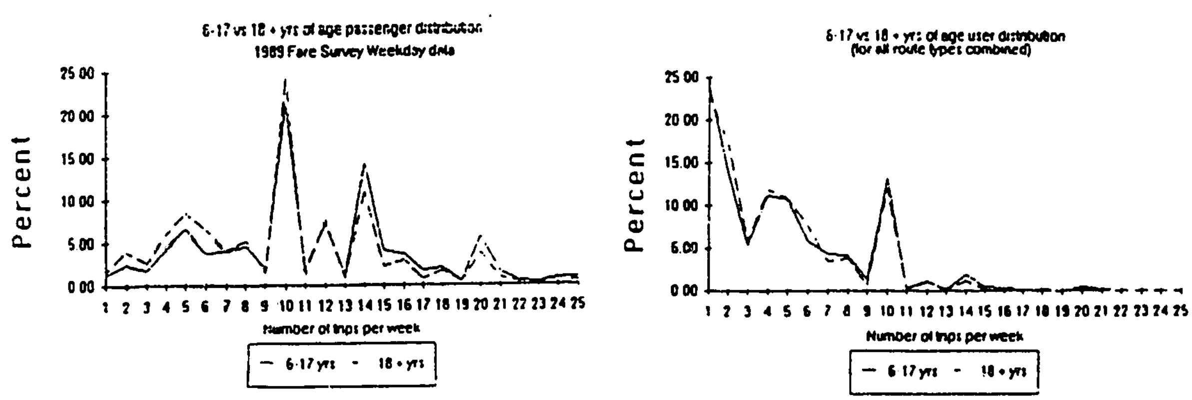


Figure 9. Comparison of 6-17 and 18+ year-old frequency of use distributions

Approximately 30% of the users from the Fare Survey are in the 6-17 age category. Increasing the Attitude and Awareness total user estimate such that 30% are 6-17 year-olds, and the remaining 70% total 142,000, has resulted in 203,000 users.

The models of Section 4.1, particularly those generated from the two-trip scenario, have agreed well with the Attitude and Awareness Survey total user estimate.

4.2. User Weekly-Frequency-of-Use Distributions

The user weekly frequency of use distributions resulting from the models of Section 3.7 are also listed in Tables 3-6. The number and percentage of users associated with each weekly frequency-of-use category, up to 25 trips taken in the past 7 days, have been calculated on a city-wide basis.

These weekly frequency-of-use categories have been grouped into the following for comparison with the Attitude and Awareness Survey:

1. light users: 1-2 trips/week
2. medium users: 3-7 trips/week
3. heavy users: 8-10 trips/week
4. very heavy users: 11+ trips/week

Attitude and Awareness Survey user estimates [7] have been shown in Table 7.

Trips/ month	Trips/ week (ave)	Freq	% of sample	Trips/ month	Trips/ week (ave)	Freq	% of sample
1	0.25	69	6.2	28	7.00	19	1.7
2	0.50	100	9.0	30	7.50	36	3.2
3	0.75	44	4.0	32	8.00	11	1.0
4	1.00	70	6.3	35	8.75	6	0.5
5	1.25	19	1.7	36	9.00	3	0.3
6	1.50	43	3.9	39	9.75	1	0.1
7	1.75	9	0.8	40	10.00	170	15.3
8	2.00	42	3.8	42	10.50	1	0.1
9	2.25	9	0.8	44	11.00	3	0.3
10	2.50	41	3.7	45	11.25	4	0.4
11	2.75	0	0.0	48	12.00	19	1.7
12	3.00	56	5.0	49	12.25	1	0.1
13	3.25	3	0.3	50	12.50	20	1.8
14	3.50	7	0.6	52	13.00	1	0.1
15	3.75	26	2.3	55	13.75	1	0.1
16	4.00	35	3.2	56	14.00	12	1.1
17	4.25	2	0.2	60	15.00	6	0.5
18	4.50	8	0.7	64	16.00	4	0.4
19	4.75	125	11.3	66	16.50	1	0.1
20	5.00	1	0.1	70	17.50	1	0.1
21	5.25	2	0.2	72	18.00	1	0.1
22	5.50	1	0.1	80	20.00	10	0.9
23	5.75	1	0.1	84	21.00	3	0.3
24	6.00	36	3.2	96	24.00	1	0.1
25	6.25	14	1.3	99	24.75	11	1.0

Table 7. Attitude and Awareness Survey weekly frequency-of-use distribution

The comparison of the Fare Survey models and the Attitude and Awareness Survey distributions is shown in Figure 10. The models have predicted percentages of users, within each category, similar to those of the Attitude and Awareness survey. The models have overestimated the percentage of heavy users (11+ trips/week), and underestimated the percentage of light users (1-2 trips/week). As a result, model calibration, described in the following Chapter 5, has been required.

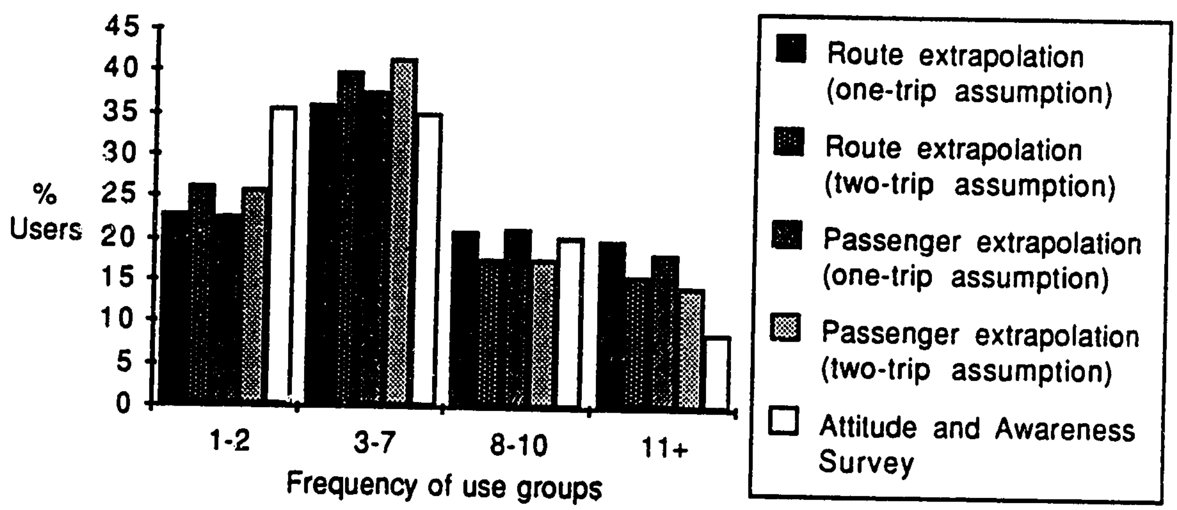


Figure 10. Uncalibrated Models and Attitude and Awareness survey weekly frequency of use distributions

4.3 Estimation of Total Ridership

In order to enhance the verification, annual rides have also been estimated using the models of Section 3.7. The users in each weekly frequency of use category have been assumed to take the same number of trips, on average, every week of the year. This has resulted in estimates of:

Model	*Rides adjusted for seasonal variation (million)
Route extrapolation (one-trip assumption)	52.5
Route extrapolation (two-trip assumption)	58.3
Passenger extrapolation (one-trip assumption)	42.6
Passenger extrapolation (two-trip assumption)	47.4

* Edmonton Transit suggested that a seasonal variation factor of 0.88 be used in the calculation. This factor, based on the ratio of the ridership level during the surveyed month to an average month, accounts for variations in ridership levels which occur throughout the year.

The Attitude and Awareness Survey yearly rides have been estimated using the assumption employed in the above Fare Survey ridership estimates. 49.4 Million rides have been estimated, based on the numbers in Table 7. No speculation has been necessary about the applicability of a seasonal variation factor to this estimate.

Edmonton Transit has provided a benchmark of 41 Million rides. This estimate has been based on operator counts.

The uncalibrated models of Section 3.7 have somewhat over-estimated the annual number of rides. However, the estimates are within the same order of magnitude as the benchmark value, and can be considered a reasonable match. The calibration process discussed in the following Chapter produces a closer fit.

5.0 MODEL CALIBRATION

The Transit User Estimation Models, validated in Chapter 4, have required calibration to increase their accuracy. The Attitude and Awareness Survey, which is already in terms of users, has been used for calibration of the models. Specifically, the models have been modified so that their user weekly frequency-of-use distributions match the results from the Attitude and Awareness Survey. This section discusses the model modification method, and the resulting changes in model estimates.

The calibration has focused initially on the route-extrapolation model. The passenger-extrapolation model has been developed after evaluation of the calibrated route-extrapolation model.

The calibration of the user estimation models using the Attitude and Awareness Survey results has been possible because of the similarity between that samples population and that of the Fare Survey. A comparison of the samples, based on the age distributions of the estimated users, is also included in this section.

5.1 Modification of User Representation Factors

User representation factors have been modified in the model to change the user weekly-frequency-of-use distribution. The goal of the modifications has been to increase the proportion of light users and decrease the proportion of very heavy users.

5.11 Expansion of Light User Proportion

Several possible approaches to calibration have been considered but the most promising appeared to be a correction for an incomplete sample. Approximately 15% of the original passenger observations have been removed because the answer given for the "how many one-way trips have you made in the past 7 days?" question has been 0 or had been set to 0 during the logic checking of questionnaires. It has not been possible to determine the exact number, but it is estimated that up to 3000 infrequent-use passengers have been removed from the sample.

This approach to calibration has been tested by increasing the user representation factor for the one-trip-per-week passengers. The goal has been to represent those passengers who had been removed from the sample. Tripling the user representation factor for the one-trip-per-week passengers has resulted in a near match of model and Attitude and Awareness Survey light user proportions. This technique may also be thought of as a tripling of the number of one-trip-per-week passengers in the sample from 214 to 642, with no change made to the user representation factors.

5.12 Reduction of Heavy User Proportion

Logic changes have not been attempted on the user representation factors associated with very heavy use passengers (11+ trips/week). These passengers have accounted for only 9% of the transit users according to the Attitude and Awareness Survey [7]. Analysis of these users' characteristics has not been considered of prime importance in the study. Therefore, the only calibration performed has been a 70% reduction in the user representation factors associated with this segment. This has resulted in a reasonable match between the models and Attitude and Awareness Survey proportions.

For the passenger-based extrapolation model, which has been developed after calibration of the route-extrapolation model, Edmonton Transit has suggested that no reduction be made to the very-heavy-use user representation factors. This advice has been incorporated in the Final Transit User Representation Model (described in Chapter 6).

5.2 Results of Calibration

Application of the user representation factor modifications discussed in sections 5.11 and 5.12 has resulted in route-extrapolation model estimates of:

Model	Users Estimated	Adjusted Annual Rides (million)
Route extrapolation (one-trip assumption)	[illegible]	38.5
Route extrapolation (two-trip assumption)	219,943	44.3
Attitude and Awareness Survey total user estimate	203,000	
Edmonton Transit Benchmark ride estimate		41.0

The user weekly frequency-of-use distributions of the Models and the Attitude and Awareness Survey are shown in Figure 11.

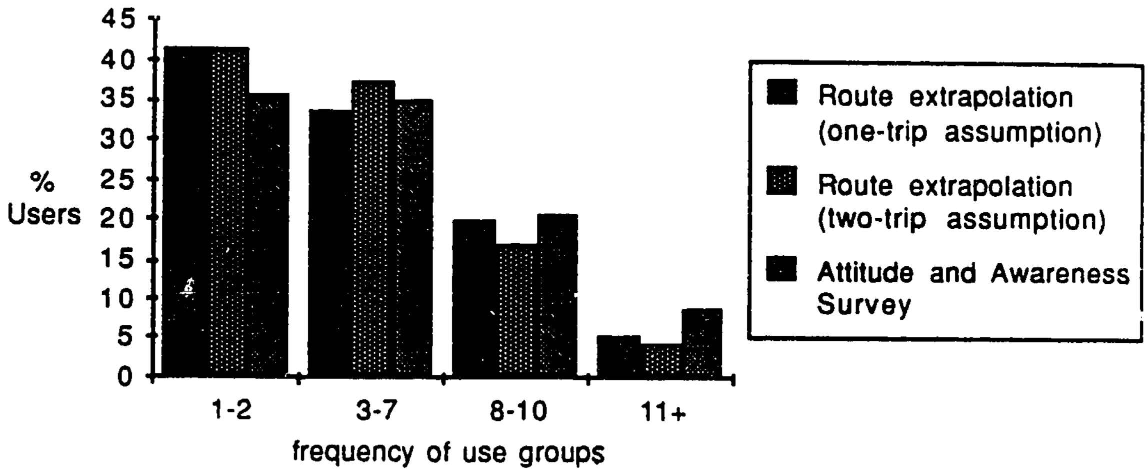


Figure 11. Calibrated Models and Attitude and Awareness survey weekly frequency of use distributions

The calibrated models have accurately matched the Attitude and Awareness Surveys total user and user weekly frequency-of-use distribution estimates. They have also agreed well with the benchmark estimate of total rides.

5.3 Comparison of Fare and Attitude and Awareness Surveys Samples

The similarity of the Fare and Attitude and Awareness survey samples has been confirmed late in the study when an age distribution was obtained for the Attitude and Awareness survey. Comparison between the estimated user age distributions, shown in figure 12, has revealed similar trends. A direct comparison has not been possible because the two surveys used different age categories.

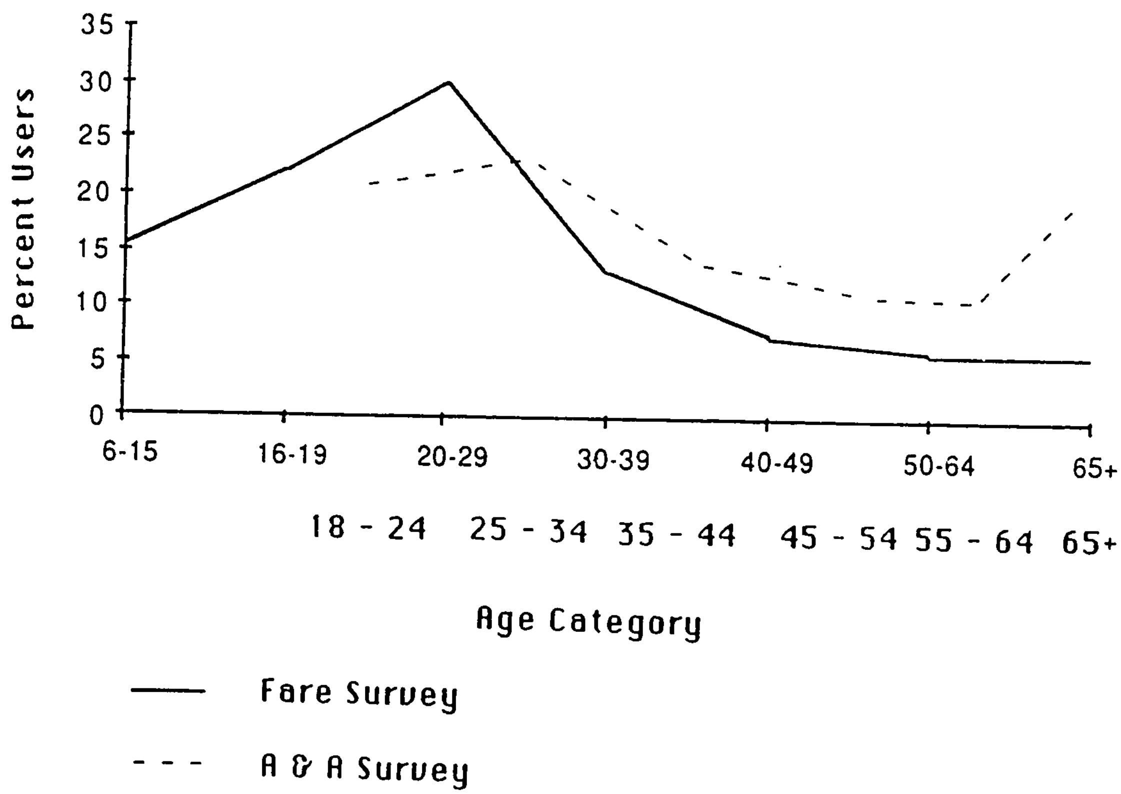


Figure 12. Fare Survey and Attitude and Awareness Survey Age Distributions

The only discrepancy between the two surveys has been the underestimation of 65+ year-old users in the Fare Survey. Edmonton Transit have stated, however, that this problem was expected, as mentioned in Section 2.1, because of the areas surveyed.

5.4 Other Comparisons

Several other tests of the models, such as a comparison between predicted and actual Adult Pass sales, have also been considered. Nevertheless, other comparisons could only be made after the appropriate transit user segments had been identified. The results have been very satisfactory, as described in Section 7.41.

6.0 FINAL TRANSIT USER ESTIMATION MODEL

Because of the better agreement of the user estimation results with the various other transit data used for comparison, the two-trip-scenario version of the Passenger-extrapolation model has been chosen for analysis of user segments. A detailed description of the model is presented in this Chapter, along with the estimates of the total number of users, distribution of weekly frequency of use, and total ridership.

Slight variations in the model have been required for the analysis of users within specific time period, destination purpose, or origin purpose segments. These modifications are also listed in this Chapter.

6.1 Passenger-Extrapolation Model (Two-trip scenario)

The two-trip-scenario version of the passenger-extrapolation model has been judged the best estimator, in combination, of total users, weekly frequency-of-use distribution, and total ridership.

The only calibration required for this model has been the tripling of the user representation factor for the one-trip-per-week passengers, described in Section 5.11. As mentioned in Section 5.12, there has been no reduction of the heavy user representation factors in the final model.

The model estimates and the benchmark comparison values are:

1. Total Users:	Model	203,750
	Attitude and Awareness Survey	203,000

2. User Weekly Frequency of Use Distribution:

	Weekly Frequency of Use			
Trips/week	1-2	3-7	7-10	11+
Model	36.2%	35.8%	15.3%	12.7%
Attitude and Awareness Survey	35.7%	34.9%	20.4%	9.0%

3. Total Yearly Rides:

Model (Seasonally Adjusted)	44.8 million
Edmonton Transit Benchmark (based on operator counts)	41.0 million

The Final User Estimation Model is shown in Table 8. The calculations of estimates for total users, user weekly frequency of use distribution, and total rides are listed in Figures 13-15.

Final Calibrated Model - passenger extrapolation 2 trip assumption model													Numbers in bold converted to users		Users						
						Passenger counts															
trips per week	7	87	ave	27	77	ave	116	165	ave	54	68	74	users per passenger		mainline	radial	express	crosstown	university	feeder	Number of users	% users
1	30	25	27.5	22	18	20	7	17	12	27	22	46	15		412.50	300.00	180.00	405.00	330.00	690.00	33816	21.20
2	80	56	68	41	61	51	23	43	33	52	56	98	4.5		306.00	229.50	148.50	234.00	252.00	441.00	24089	15.10
3	75	43	59	28	40	34	6	23	14.5	35	61	56	2.17		128.03	73.78	31.47	75.95	132.37	121.52	8476	5.31
4	145	79	112	70	67	68.5	17	46	31.5	87	159	140	2		224.00	137.00	63.00	174.00	318.00	280.00	17231	10.80
5	157	15:	154	110	102	106	49	92	70.5	128	189	197	1.27		195.58	134.62	89.54	162.56	240.03	250.19	15608	[illegible]
6	112	92	102	86	94	90	15	58	36.5	92	170	125	1.17		119.34	105.30	42.71	107.64	198.90	146.25	10501	6.58
7	101	74	87.5	40	53	46.5	27	45	36	68	94	108	0.82		71.75	38.13	29.52	55.76	77.08	88.56	5216	3.27
8	122	63	92.5	57	80	68.5	37	53	45	89	98	113	0.75		69.38	51.38	33.75	66.75	73.50	84.75	5555	3.48
9	39	18	28.5	16	27	21.5	19	11	15	33	24	35	0.56		15.96	12.04	8.40	18.48	13.44	19.60	1282	0.80
10	404	359	382	203	368	286	175	330	253	376	534	632	0.5		190.75	142.75	126.25	188.00	267.00	316.00	17483	10.96
11	26	24	25	18	20	19	14	11	12.5	23	33	40	0.45		11.25	8.55	5.63	10.35	14.85	18.00	987	0.62
12	146	155	151	65	118	91.5	31	66	48.5	121	137	255	0.42		63.21	38.43	20.37	50.82	[illegible]	107.10	4900	3.07
13	17	17	17	12	14	13	3	8	5.5	21	21	40	0.38		6.46	4.94	2.09	7.98	[illegible]	15.20	624	0.39
14	257	198	228	108	227	168	48	84	66	219	185	405	0.36		81.90	60.30	23.76	78.84	[illegible]	145.80	6685	4.19
15	58	36	47	33	39	36	12	25	18.5	51	48	98	0.33		15.51	11.88	6.11	16.83	[illegible]	32.34	1406	0.88
16	89	46	67.5	26	57	41.5	12	22	17	41	57	100	0.31		20.93	12.87	5.27	12.71	[illegible]	31.00	1502	0.94
17	25	17	21	5	18	11.5	3	3	3	13	23	41	0.29		6.09	3.34	0.87	3.77	6.67	11.89	471	0.30
18	40	29	34.5	25	25	25	4	12	8	37	36	60	0.28		9.66	7.00	2.24	10.36	10.08	16.80	807	0.51
19	10	7	8.5	5	10	7.5	1	0	0.5	1	4	12	0.26		2.21	1.95	0.13	0.26	1.04	[illegible]	148	0.09
20	124	56	90	48	62	55	6	30	18	70	81	148	0.25		22.50	13.75	4.50	17.50	20.25	37.00	1690	1.06
21	26	9	17.5	11	19	15	2	7	4.5	11	25	41	0.24		4.20	3.60	1.08	2.64	6.00	9.84	398	0.25
22	16	9	12.5	6	6	6	0	1	0.5	8	4	11	0.23		2.88	1.38	0.12	1.84	0.92	2.53	153	0.10
23	1	4	2.5	1	6	3.5	0	0	0	2	5	9	0.22		0.55	0.77	0.00	0.44	1.10	1.98	70	0.04
24	22	5	13.5	5	17	11	1	1	1	12	11	27	0.21		2.84	2.31	0.21	2.52	2.31	5.67	235	0.15
25	15	16	15.5	9	9	9	0	3	1.5	9	5	28	0.2		3.10	1.80	0.30	1.80	1.00	[illegible]	208	0.13
	2137	1508	1863	1050	1557	1304	512	[illegible]	751.5	1026	2082	2865		#users	1986.56	1397.355	825.79	1706.8	2132.17	2881.74	159542	100.00
													x rep routes		18.17	19.28	16.81	8.56	10.7	10.47		
													x scaling factor		1.86	2.04	1.21	1.61	1.61	1.86		
															67138.18	54959.65	16796.65	23522.43	36730.89	56119.58		
															255267	Weekday users citywide						
																allow factor of 1.6 for transfers						
															159542	Weekday users citywide						

Table 8. Final Calibrated Model: Passenger-extrapolation (two trip assumption)

Final Model - Passenger Extrapolation (two trips assumption) total user estimate:

a) LRT estimate (treating as a mainline route)

LRT => 22,000 boardings

Mainlines: 62,889 boardings => 67,138/1.6 = 41,961 users (Weekday)

22,000/62,889 X 41,961 =	14,679 users
Saturday (40% of weekday)	5,872 users
Sunday (20% of weekday)	2,936 users
	23,487 users

b) Industrial estimate (treating as a feeder route)

Industrial => 2,506 boardings

Feeders: 55,775 boardings => 56,120/1.6 = 35,075 users (Weekday)

2,506/55,775 * 35,075 users = 1,576 users

c) Weekend users

Weekday => 159,542 users

Saturday	(40% of a weekday):	159,542/5 X 0.40 = 12,763 users
Sunday	(20% of a weekday):	159,542/5 X 0.20 = 6,382 users
		19,145 users

d) Summation

Weekday	159,542 users
Weekend	19,145 users
LRT	23,487 users
Industrial routes	1,576 users
	203,750 users

Figure 13. Final model total user estimate

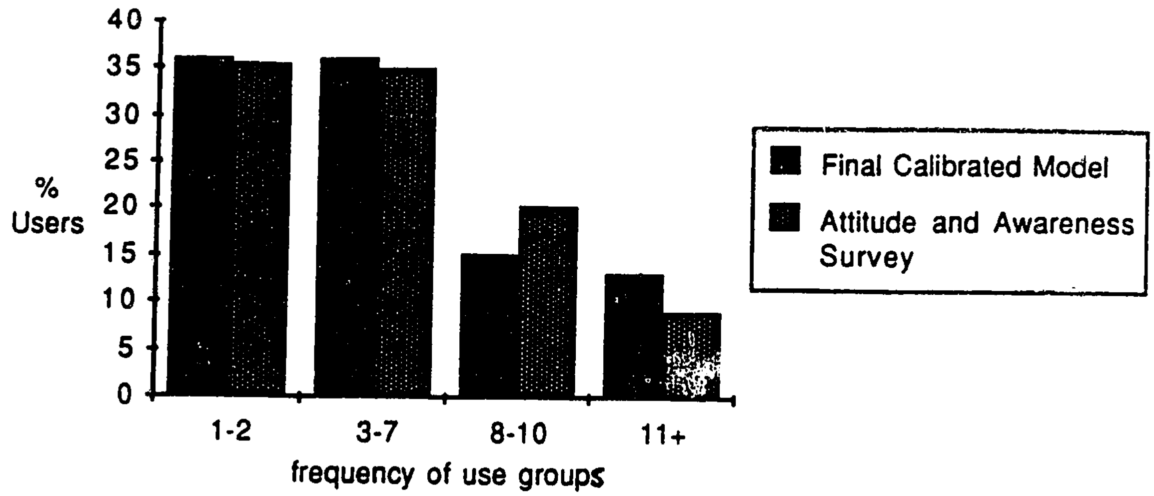


Figure 14. Final Model and Attitude and Awareness Survey weekly frequency of use distributions

<u>Calculation of total rides using final model</u>

Weekday rides:	45.5 Million
Saturday (40% of a weekday)	3.6 Million
Sunday (20% of a weekday)	<u>1.8 Million</u>
	50.9 Million

Seasonal variation factor of 0.88 => **<u>44.8 Million rides</u>**

Figure 15. Calculation of total rides using Final Model

6.2 Model Adjustments for Specific Segment Analysis

The model of Section 6.1 has estimated the number of users based on a full day passenger sample. Its purpose has been estimation of the weekly frequency-of-use distribution, total number of transit users, and total yearly ridership.

Specific segments have also been analyzed in this study. The following characteristics have been used to segment users:

- time of travel
- purpose at origin
- purpose at destination
- weekly frequency of use
- method of payment
- age of user

Analysis of specific segments using the full-day model has not been considered appropriate because of the assumption of overcounting which has been used to develop the user representation factors: a specific passenger segment will have far less passenger overcounting than a full day sample. Therefore, specific models have been developed. The overall structure of these models has been similar to the full day model; the difference has been in the way the user representation factors have been developed.

6.21 Time-Period Segmentation Model

For analysis of specific time segments, the passenger sample data has been divided into the following 5 groups:

Morning Peak:	6 a.m. - 9 a.m.
Afternoon Off-peak:	9 a.m. - 3 p.m.
Evening Peak:	3 p.m. - 6 p.m.
Evening Off-peak:	6 p.m. - 9:30 p.m.
Late Night:	9:30 p.m. - 11 p.m.

In some time periods, only the trip to the destination has been likely, e.g., a Morning Peak trip to Work. In other periods, trips have likely been made to and from the destination, e.g., an Afternoon Off-peak trip to and from Shopping.

Two models have been developed for each time period because of the uncertainty of the number of trips taken. Some passengers may make even more than two trips during a given time period; the number of these passengers has been assumed small enough that additional models have not been required.

The user representation factors developed in these models have differed only with respect to the reduction factors. For the models which assume only one trip during the time period, no reduction factor has been applied because of no theoretical (every user has been assumed as taking only one trip) chance of overcounting. The two-trip-per-time-period model has a reduction factor of 0.5 (1 out of 2 trips overcounted) associated with each user representation factor (except for the weekly frequency of use category of one). The expansion factors in these models are identical to those applied in the full day model. Table 9 illustrates the user representation factors for the one-trip and two-trip-per-time-period models.

User representation factors: 1 trip per time period assumed

Passenger Type (trips/week)	Number of users represented	Passenger Type (trips/week)	Number of users represented
1	15.00	13	1.00
2	5.00	14	1.00
3	2.50	15	1.00
4	2.50	16	1.00
5	1.67	17	1.00
6	1.67	18	1.00
7	1.25	19	1.00
8	1.25	20	1.00
9	1.00	21	1.00
10	1.00	22	1.00
11	1.00	23	1.00
12	1.00	24	1.00
		25	1.00

User representation factors: 2 trips per time period assumed

Passenger Type (trips/week)	Number of users represented	Passenger Type (trips/week)	Number of users represented
1	15.00	13	0.50
2	4.50	14	0.50
3	2.00	15	0.50
4	2.00	16	0.50
5	1.17	17	0.50
6	1.17	18	0.50
7	0.75	19	0.50
8	0.75	20	0.50
9	0.50	21	0.50
10	0.50	22	0.50
11	0.50	23	0.50
12	0.50	24	0.50
		25	0.50

Table 9. User Representation Factors for One-trip-per-time period and Two-trip-per-time period models

6.22 Origin or Destination Purpose Segment Models

The model which has been developed to convert a specific origin or destination segment of passengers into the corresponding number of users is the same as the one-trip-per-time-period model described in Section 6.21 above. The expansion factors are the same as in the full-day model, while no reduction factors have been applied because the specific segmentation of the trip has implied little chance of passenger overcounting. It has been assumed that the small portion of passengers who have a specific origin or destination repeated during the day would not justify development of a separate model.

7.0 USER SEGMENTATION

The model presented in Chapter 6 has been used to analyze specific user segments.

Before discussing the results, the categorization of responses is explained. This categorization effects the type of passengers in the various segments. Some passenger characteristics have natural boundaries due to the possible answers to survey questions. Others have required development of logical boundaries because of the unmanageable number of segments which exist within that characteristic, e.g. time of travel.

Additionally, the number of questions included in the Fare Survey has allowed generation of a large number of extremely specific, but statistically unreliable, segments. The potential number of segments has been estimated, to allow explanation of the level of segmentation which may occur before the statistical reliability of the results becomes questionable.

A graphical display is superior to cross-tabulation matrices when interpreting the segment analysis results. The methods in which these results have been presented, in particular the application of Area, Cumulative Area, and Bar graphs, are also included in this section.

The results of the user segmentation analysis are presented in the final part of this Chapter. The following characteristics have been analyzed:

- 1988 versus 1989 fare payment methods within different time periods
- fare payment methods of post-secondary students
- fare payment methods for weekly frequencies of use within different time periods

Various other segments have also been analyzed to illustrate potential uses of the model.

7.1 Categorization of Responses

Boundaries have been created for some of the characteristics of the Fare Survey passengers. Other characteristics have natural boundaries associated with the possible responses to the survey questions. The boundaries represent logical divisions of passengers, based on the characteristics examined by the questions.

Boundaries have been developed or already exist for the following passenger characteristics:

- number of one-way trips taken in the past 7 days
- time of travel
- method of fare payment
- purpose at origin at start of trip
- purpose at destination of trip
- number of transfers taken during this trip
- number of one-way trips taken today
- age of passenger
- sex of passenger

Responses to the "number of trips in the past 7 days" question have been divided into the following categories:

light users:	1-2 trips/week
medium users:	3-7 trips/week
heavy users:	8-10 trips/week
very heavy users:	11+ trips/week

Passengers time of travel has been divided into the following periods:

Morning Peak:	6 a.m. - 9 a.m.
Morning Off-peak:	9 a.m. - 3 p.m.
Evening Peak:	3 p.m. - 6 p.m.
Evening Off-peak:	6 p.m. - 9:30 p.m.
Late Night:	9:30 p.m. - 11 p.m.

Other passenger characteristics have natural boundaries associated with the possible responses to their respective questions.

7.2 Calculation of Segmentation Potential

The total number of segments which may be analyzed in this study has been directly related to the number of possible segments of each passenger characteristic examined in the Fare Survey. Each passenger characteristic has a finite number of segments. The number of possible segments of two of the characteristics, weekly frequency of use, and time of travel, have been reduced by the development of logical boundaries. A conservative estimate of the total number of segments which may be examined is:

	Time of travel:	5 classes
X	Weekly frequency of use:	4 classes
X	Fare payment method:	11 classes
X	Number of transfers:	5 classes
X	Purpose at origin:	8 classes
X	Purpose at destination:	8 classes
X	Age:	7 classes
X	Sex:	2 classes

ie. 985,600 segments

The statistical reliability of some user estimates has diminished with each successive segmentation. This has occurred because the number of passengers in the segments used to estimate these users decreases.

Beyond three levels of segmentation, the segments contain small numbers of passengers. In fact, the majority of these segments are empty, i.e. contain zero passengers. The non-zero segments do not contain enough passengers to be statistically reliable. This fact restricts the use of the model.

7.3 Method of Presenting Results

The large number of segments which have been analyzed during the study have resulted in a significant number of cross-tabulation matrices of users. Graphical displays allow easier interpretation of the segmentation results. Therefore Area, Cumulative Area, and Bar graphs have been used to display the estimated users in various segments

7.31 Use of Area Graphs

Area graphs have been used when investigating patterns in the data. Use of these graphs also helps identify the internal distribution of user categories within the overall pattern, such as the fare payment methods of post-secondary origin users illustrated later in Figure 20.

7.32 Use of Cumulative Area Graphs

Cumulative Area graphs have been used when the total number of users is required. In addition, one or more categories of user can be compared to the total using this method of presentation, such as the fare payment methods of post=secondary origin users illustrated later in Figure 21.

7.33 Use of Bar Graphs

Bar Graphs have been employed when comparison is required within graphs. Also, by standardizing the axis values, comparisons among graphs is possible, such as the fare payment methods of post-secondary users illustrated later in Figures 22-2

7.4 Results of Segmentation Analysis

7.41 Impact of Fare Increase

A goal of the segment analysis has been to identify any internal changes in fare payment which may have resulted due to the fare increase in January 1989. Specifically, payment methods within predetermined time periods have been investigated.

The time-of-travel models, illustrated in section 6.21, have been used for this analysis. The one-trip model has been used for the 6 a.m. - 9 a.m. and 3 p.m. - 6 p.m. periods, and the two-trip model for the 9 a.m. - 3 p.m. and 6 p.m. - 9:30 p.m. periods. The models chosen have represented the most probable number of trips taken during a particular time period.

Only 2,000 to 4,000 users have been estimated for the 9:30 p.m. - 11 p.m. period. It has therefore not been analyzed.

Estimates of the absolute number of city-wide users within each time segment, from both the 1988 and 1989 surveys, have been shown in Figures 16-19.

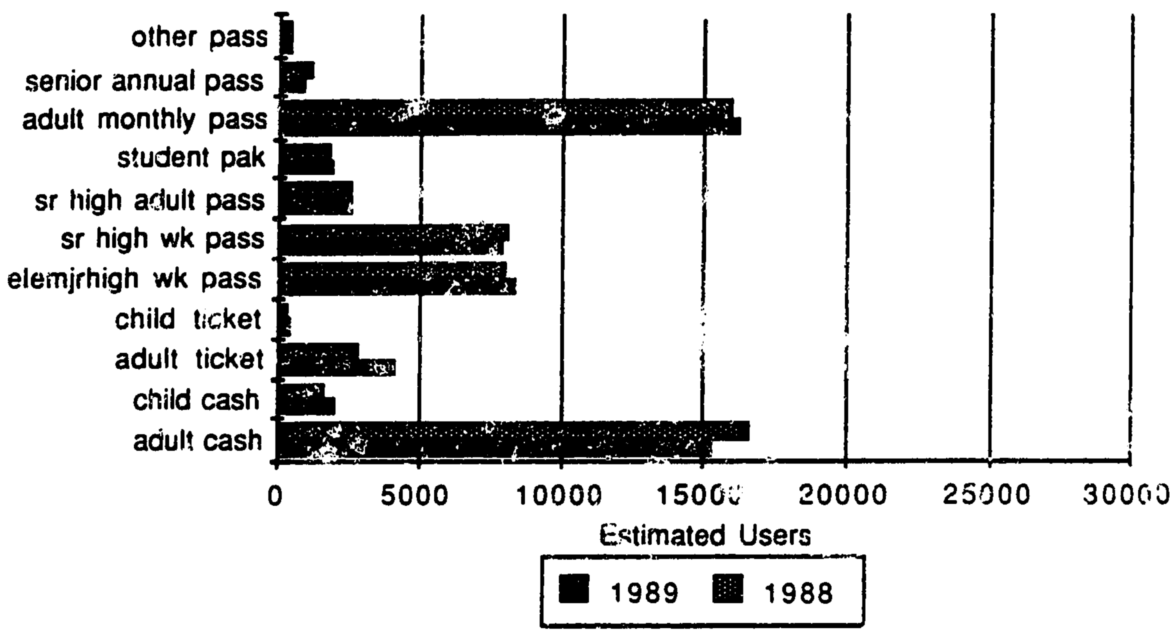


Figure 16. 6 a.m. - 9 a.m. Fare Distribution Comparison

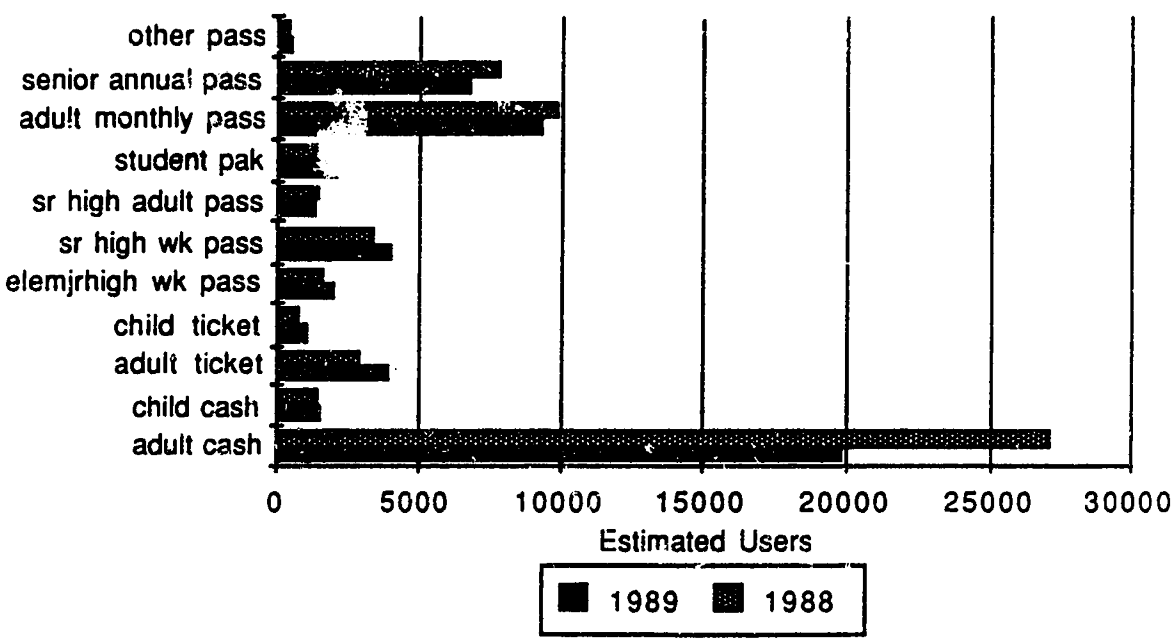


Figure 17. 9 a.m. - 3 p.m. Fare Distribution Comparison

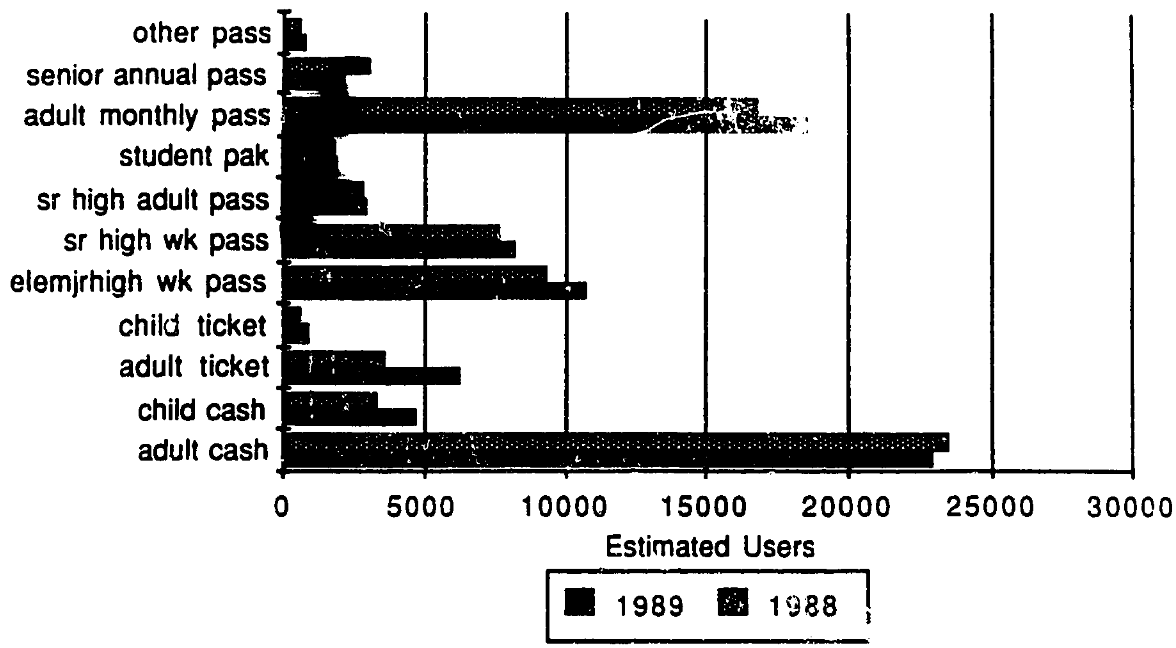


Figure 18. 3 p.m. - 6 p.m. Fare Distribution Comparison

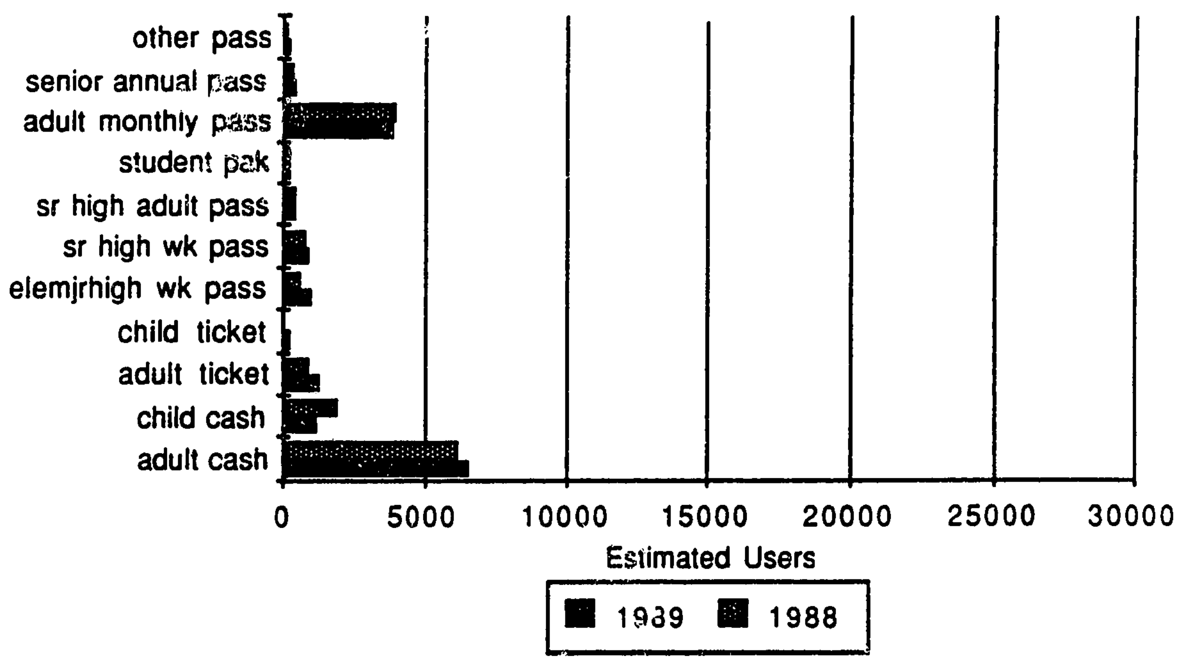


Figure 19. 6 p.m. - 9:30 p.m. Fare Distribution Comparison

The largest change has been the reduction in cash payment users during the off-peak period of 9 a.m. - 3 p.m., illustrated in Figure 17. It appears as if a large segment of these users either changed mode or stopped travelling altogether due to the fare increase. Changes in other fare categories have been less pronounced and have required some form of statistical testing to determine if a significant change has occurred.

7.411 Statistical Comparison of 1988 and 1989 Fare Payment Methods within Different Time Periods

The fare payment methods of the 1988 and 1989 user samples have been statistically compared. These user samples have been developed by applying the user representation factors of the full-day model to the passenger data. The extrapolation and scaling factors of the full-day model have not been used to expand the user sample city wide. Statistical comparison of the transformed passenger sample has been judged appropriate due to the success of full-day model during both the validation process, described in Chapter 4, and the comparison of estimated vs actual non-cash payment users, to be discussed later in Section 7.45.

The samples have been compared by proportions of each fare payment method. Sample users have first been divided into cash and non-cash categories. Hypothesis testing has then been used to determine if statistically significant differences exist between sample proportions for each category [8].

For example, if we want to know if the 1988 population proportion of a given fare type, Px, is significantly smaller than the 1989 population proportion, Py, then we want to be able to reject the null hypothesis (Ho: Px >= Py), with a high degree of confidence.

The same analysis is performed if we want to know if the 1989 population proportion of a fare payment, Py, is smaller than the 1988 population proportion. In this case, we want to reject the null hypothesis (Ho: Px <= Py), with a high degree of confidence.

The smallest significance level that we can reject the null hypothesis, Ho, is known as the p-value of the test. Therefore, if we reject Ho at a p-value of 3%, we have only a 3% chance of being wrong. We would not be able to reject the null hypothesis at a 2% level of significance.

The results of the testing may be interpreted in the following way: if a 1988 *sample* fare proportion is greater than the corresponding 1989 *sample* fare proportion, the test determines the probability of being wrong if the hypothesis, that the 1989 *population* fare proportion is greater than or equal to the 1988 *population* fare proportion, is rejected i.e. the p-value of the test. For instance, if the hypothesis, that the proportion of 6 a.m. - 9 a.m. adult cash users in the 1989 population is greater than or equal to that of the 1988 population, is rejected, there is only a 2% chance of error (shown in Table 10).

The results of the statistical testing for the 6 a.m. - 9 a.m. period are shown in the Table 10.

Payment

Cash	1988	1989	1988 (%)	1989 (%)	Common prop.	Z stat.	p-value (%)
adult cash	1009	961	28.2	25.9	0.270	2.20	2
child cash	92	122	2.6	3.3	0.029	-1.81	4
non-	2476	2625	69.2	70.8	0.700	-1.46	7
	3577	3708	100.0	100.0			

Non Cash	1988	1989	1988 (%)	1989 (%)	Common prop.	Z stat.	p-value (%)
adult ticket	176	263	7.1	10.0	0.086	-3.70	0
child ticket	22	29	0.9	1.1	0.010	-0.78	22
elemjrhigh pass	465	492	18.8	18.7	0.188	0.03	49
sr high wk pass	479	490	19.3	18.7	0.190	0.62	27
sr high A. pass	150	152	6.1	5.8	0.059	0.40	34
student pak	109	120	4.4	4.6	0.045	-0.29	39
adult m. pass	984	1000	39.7	38.1	0.389	1.21	11
senior a. pass	64	54	2.6	2.1	0.023	1.25	11
other pass	27	25	1.1	1.0	0.010	0.49	31
	2476	2625	100.0	100.0			

Table 10. Statistical Comparison of 6 a.m. - 9 a.m. fare payment methods (1988 vs 1989)

The fare payment methods which changed significantly (using a 5% probability of error), and their corresponding p-values, are:

Fare	p-value (%)
Adult Cash	2
Child Cash	4
Adult Ticket	0

The decrease in users paying by adult cash has been offset by increased use of the adult ticket. This change is reasonable given that users in this time period are predominantly travelling to work or school and therefore cannot quit making the trip altogether.

The results of the statistical testing for the 9 a.m. - 3 p.m. period are shown in the Table 11.

Payment Cash	1988	1989	1988 (%)	1989 (%)	Common prop.	Z stat.	p-value (%)
adult cash	1523	1124	46.4	37.7	0.423	6.91	0
child cash	88	93	2.7	3.1	0.029	-1.05	15
non-cash	1673	1761	50.9	59.1	0.548	-6.50	0
	3284	2978	100.0	100.0			

Non Cash	1988	1989	1988 (%)	1989 (%)	Common prop.	Z stat.	p-value (%)
adult ticket	164	222	9.8	12.6	0.112	-2.60	0
child ticket	43	60	2.6	3.4	0.030	-1.44	7
elemjrhigh pass	94	110	5.6	6.2	0.059	-0.78	22
sr high wk pass	191	229	11.4	13.0	0.122	-1.42	8
sr high A. pass	79	76	4.7	4.3	0.045	0.57	28
student pak	85	128	5.1	7.3	0.062	-2.66	0
adult m. pass	562	530	33.6	30.1	0.318	2.20	1
senior a. pass	432	379	25.8	21.5	0.236	2.97	0
other pass	23	27	1.4	1.5	0.015	-0.39	35
	1673	1761	100.0	100.0			

Table 17. Statistical Comparison of 9 a.m. - 3 p.m. fare payment methods (1988 vs 1989)

The fare payment methods which changed significantly (using a 5% probability of error), and their corresponding p-values, have been:

Fare	p-value (%)
Adult Cash	0
Adult Ticket	0
Student Pak	0
Adult Monthly Pass	1
Senior Annual Pass	0

Additionally, use of non-cash fares in aggregate changed significantly, with a p-value of 0%.

The major decrease in adult cash payment users, shown in Figure 17 and validated statistically above, was also accompanied by an increase in adult ticket use. This increase, however, was not sufficient to account for the lost cash payment users.

The decrease in Adult and Senior Annual Pass users appears to indicate a mode switch or termination of travel during this period by some of the users. The increase in Student Pak use is reasonable given the typical financial constraints of students and their lack of choice in terminating the trip altogether.

The results of the statistical testing for the 3 p.m. - 6 p.m. period are shown in the Table 12.

Payment Cash	1988	1989	1988 (%)	1989 (%)	Common prop.	Z stat.	p-value (%)
adult cash	1444	1419	32.8	29.3	0.310	3.64	0
child cash	196	283	4.5	5.9	0.052	-3.01	0
non-cash	2756	3135	62.7	64.8	0.638	-2.12	2
	4396	4837	100.0	100.0			

Non Cash	1988	1989	1988 (%)	1989 (%)	Common prop.	Z stat.	p-value (%)
adult ticket	221	383	8.0	12.2	0.103	-5.30	0
child ticket	35	53	1.3	1.7	0.015	-1.33	9
elemjrhigh pass	536	624	19.4	19.9	0.197	-0.44	33
sr high wk pass	458	490	16.6	15.6	0.161	1.03	15
sr high A. pass	165	166	6.0	5.3	0.056	1.15	13
student pak	106	116	3.8	3.7	0.038	0.29	39
adult m. pass	1020	1133	37.0	36.1	0.365	0.69	25
senior a. pass	175	124	6.3	4.0	0.051	4.18	0
other pass	40	46	1.5	1.5	0.015	-0.05	48
	2756	3135	100.0	100.0			

Table 12. Statistical Comparison of 3 p.m. - 6 p.m. fare payment methods (1988 vs 1989)

The fare payment methods which changed significantly (using a 5% probability of error), and their corresponding p-values, have been:

Fare	p-value (%)
Adult Cash	0
Child Cash	0
Adult Ticket	0
Senior Annual Pass	0

Additionally, use of non-cash fares in aggregate changed significantly, with a p-value of 2%.

The decrease in adult cash users and increase in adult ticket users mirrors that of the am peak period. These are predominantly users, identified previously in the am peak period, who are returning from work or school.

The decrease in Senior Annual Pass use probably indicates a further loss of the off-peak user segment: these users likely made the initial trip during the 9 a.m. - 3 p.m. period, and are returning home during the pm peak.

The results of the statistical testing for the 6 p.m. - 9:30 p.m. period are shown in the Table 13.

Payment Cash	1988	1989	1988 (%)	1989 (%)	Common prop.	Z stat.	p-value (%)
adult cash	352	362	41.1	40.9	0.410	0.09	46
child cash	108	62	12.6	7.0	0.098	3.94	0
non-cash	397	462	46.3	52.1	0.493	-2.43	1
	857	886	100.0	100.0			

Non Cash	1988	1989	1988 (%)	1989 (%)	Common prop.	Z stat.	p-value (%)
adult ticket	46	66	11.6	14.3	0.130	-1.17	12
child ticket	4*	13*	1.0	2.8	0.020	-1.90	3
elemjrhigh pass	32	52	8.1	11.3	0.098	-1.57	6
sr high wk pass	42	50	10.6	10.8	0.107	-0.11	46
sr high A. pass	20	22	5.0	4.8	0.049	0.19	43
student pak	11	13	2.8	2.8	0.028	-0.04	48
adult m. pass	218	214	54.9	46.3	0.503	2.51	1
senior a. pass	17	20	4.3	4.3	0.043	-0.03	49
other pass	7	12	1.8	2.6	0.022	-0.83	20
	397	462	100.0	100.0			

Table 13. Statistical Comparison of 6 p.m. - 9:30 p.m. fare payment methods (1988 vs 1989)

The fare payment methods which changed significantly (using a 5% probability of error), and their corresponding p-values, have been:

Fare	p-value (%)
Child Cash	0
Child Ticket	3
Adult Monthly Pass	1

Additionally, use of non-cash fares in aggregate changed significantly, with a p-value of 1%.

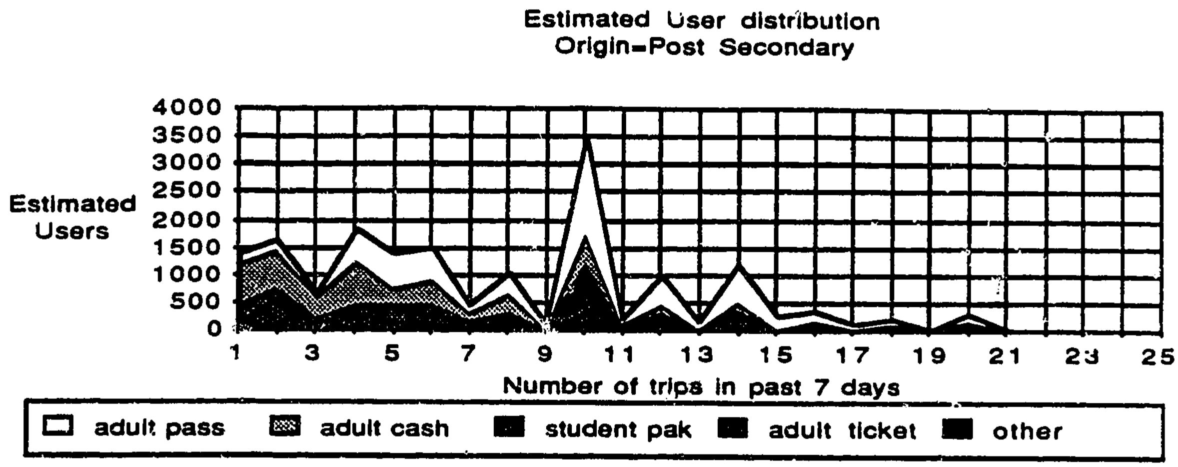
A decrease in Child Cash users was offset by an increase in Child Ticket users. This change is reasonable given the financial constraints of the users in this category.

The use of the Adult Monthly Pass decreased statistically significantly only in this time period. Analysis of all the time periods reveals, however, that use of this pass decreased in each case. Correspondingly, Adult Ticket use increased in all time periods, indicating that some users, likely those whose level of transit use marginally justified purchase of a bus pass before the fare increase, now judged the Adult Ticket economically superior.

7.42 Post-secondary user fare payment methods

Post-Secondary students have been investigated regarding this group's fare payment system. The specific purpose at origin or purpose at destination model of Section 6.22 has been used for this analysis. Users whose origin or destination was post-secondary have been segmented according to their fare payment methods and weekly frequency of use.

All of the segments analyzed have resulted in nearly identical distributions of post-secondary origin and post-secondary destination users, as illustrated by Figure 20.



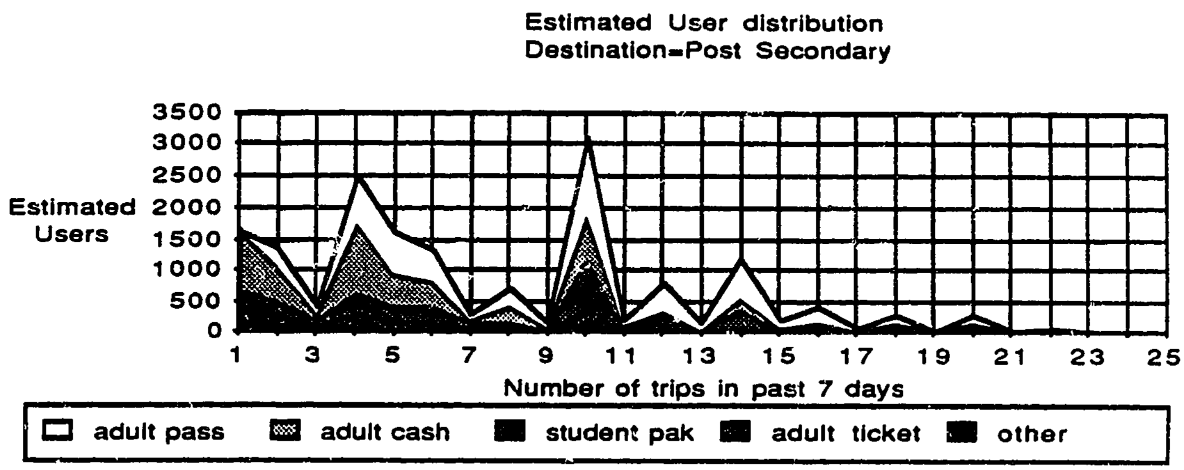
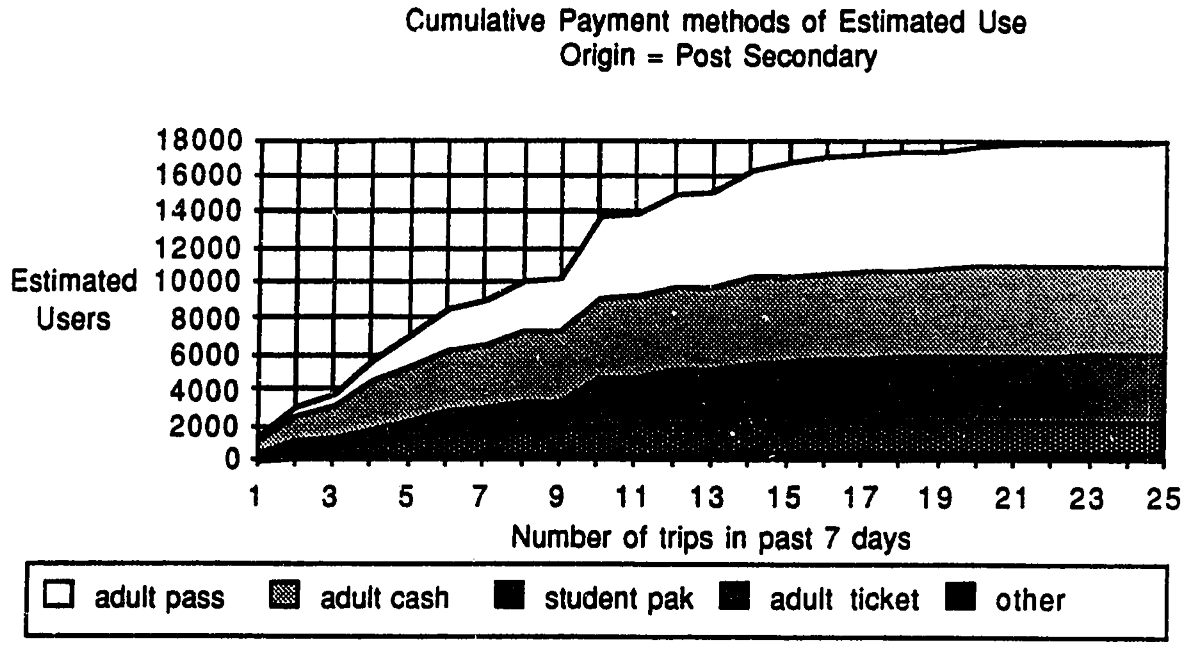


Figure 20. Comparison of origin=post secondary and destination=post secondary distributions

The weekly frequency-of-use distributions differ from the overall pattern of the entire user sample in that the proportion of infrequent users is smaller for the post secondary users. This result is consistent with an assumed travel level of at least two transit trips per weekday for most post secondary students and employees.

Figure 21 shows that approximately 1,000 more post-secondary-origin users overall have been estimated than the 17,000 predicted post-secondary destination users, indicating that they may have received a car-ride for the initial trip; however, the similarity of the distributions confirms that most passengers were surveyed on their trips to and from the post-secondary institutions. Therefore, to avoid unnecessary repetition, only the characteristics of the post-secondary-origin users will be discussed.



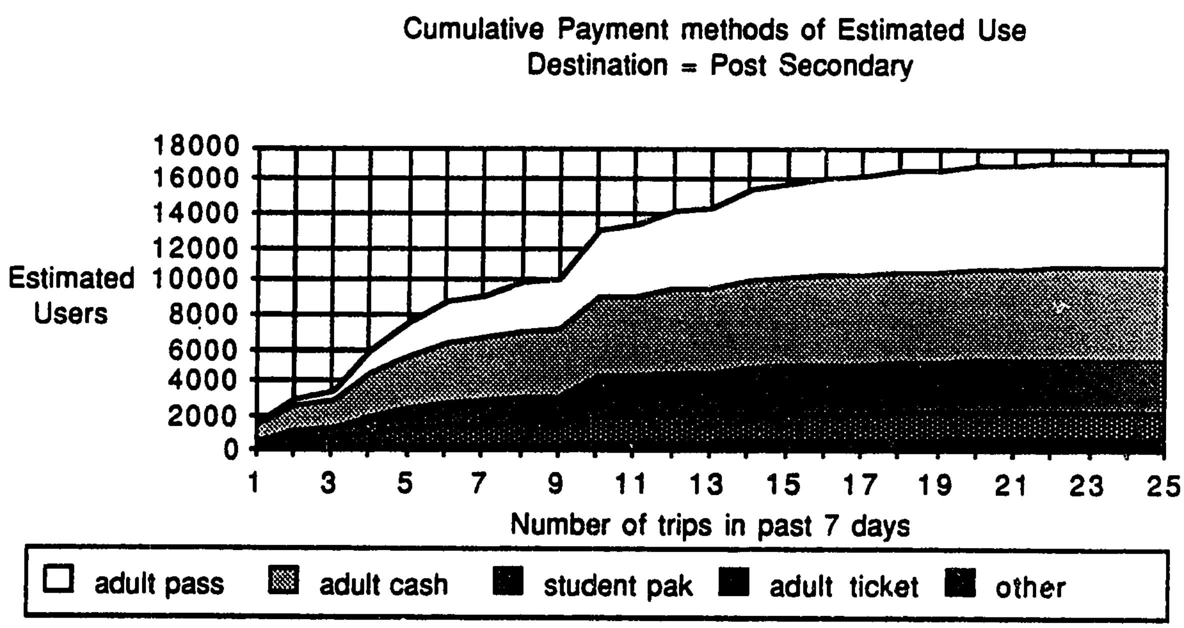


Figure 21. Comparison of origin=post-secondary and destination=post-secondary cumulative fare payment methods

The post secondary-origin users have been analyzed regarding preferred fare payment methods after segmentation into the following 3 weekly frequency-of-use groups:

- light to medium users (1-8 trips/week)
- heavy users (9-10 trips/week)
- very heavy users (11+ trips/week)

Figure 22 illustrates the fare payment methods of post-secondary-origin users who take 1-8 trips/week.

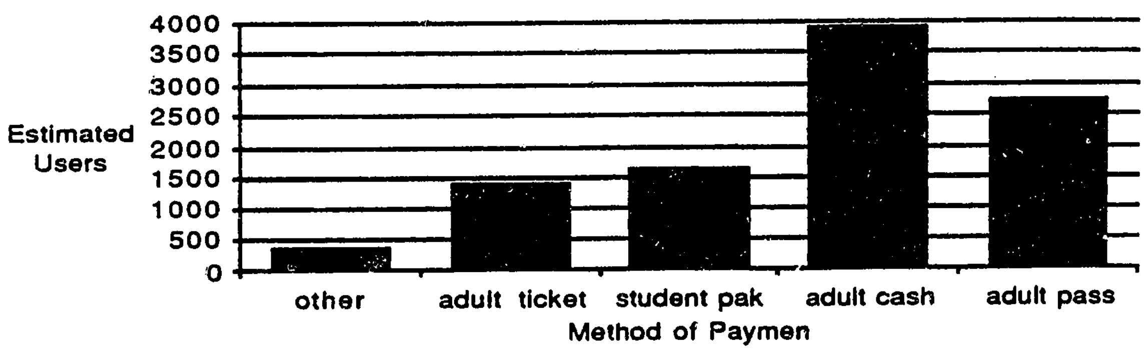


Figure 22. Origin=post-secondary, 1-8 trips/week

Adult Cash use dominates this segment as expected given the number of trips that must be taken before an Adult Pass becomes the economically superior payment method. What is surprising is that the Adult Pass and Student Pak were more popular than the Adult Ticket. A possible explanation is that some users (those using the Adult Pass or Student Pak) who normally make more trips per week were surveyed during a non-typical week of travel. Another scenario is that the perceived effort required to purchase the Adult Tickets outweighs the savings associated with this method of payment (11 one-way trips for the price of 10).

Fare payment methods of Post-secondary users taking 9-10 trips/week have been shown in Figure 23.

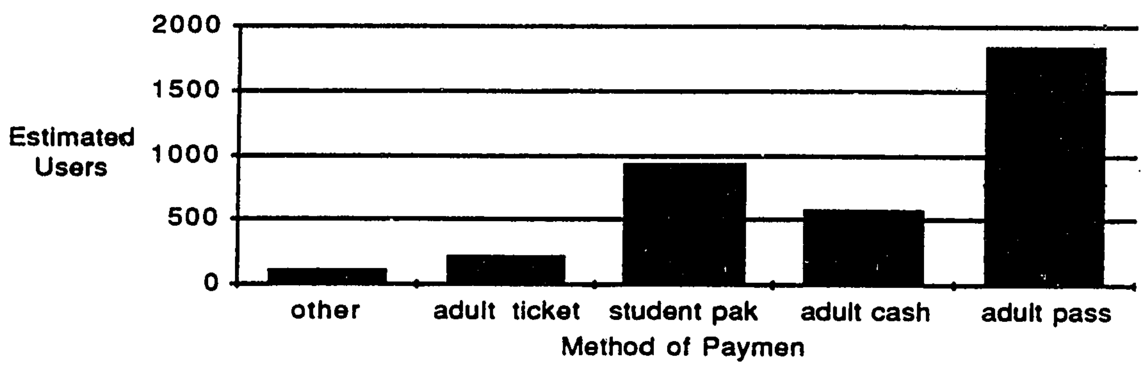


Figure 23. Origin=post-secondary, 9-10 trips/week

The popularity of the Adult Pass and Student Pak with this segment is consistent with the level of transit use. Adult Cash being used more than Adult Ticket is further evidence of the lack of perceived benefit associated with the Adult Ticket.

Fare payment methods of Post-secondary users taking 11+ trips/week are listed in Figure 24.

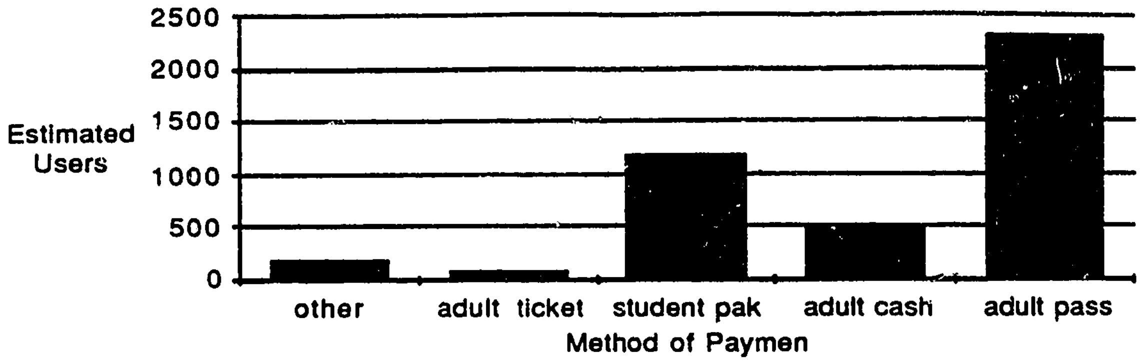


Figure 24. Origin=post-secondary, 11+ trips/week

Again, as expected, the Adult Pass and the Student Pak are the most popular fare payment methods. The Adult Cash payment users in this segment may be more infrequent users who were surveyed during a non-typical week of travel.

For all segments, use of the Adult Pass was greater than the Student Pak (which is just the purchase of 4 consecutive months Adult Passes for a slight discount). The discount associated with the Student Pak may not be large enough to attract more of the Adult Pass market. The time at which the Student Paks are sold competes with other major student expenditures including books and tuition, and therefore may require perception as a larger savings than it currently is, if use of the fare is to increase. Additionally, purchase of the Student Pak obligates students to the mode of transit for 4 months and this may be unsatisfactory during certain seasons of the year.

On an aggregate level, 3,200 post-secondary destination and 3800 post-secondary origin users overall utilized the Student Pak. Comparison of these estimates with actual Student Pak sales in November 1987 (3,630) further validates the Transit user estimation model.

7.43 Fare Distribution of Specific Frequency of Use Groups within Different Time Periods

Fare payment methods of specific frequency of use groups have been analyzed in relation to time of travel. Frequency of use categories of 1-2, 3-7, 8-10, and 11+ trips/week, within the time periods of 6 a.m. - 9 a.m., 9 a.m. - 3 p.m., 3 p.m. - 6 p.m., and 6 p.m. - 9:30 p.m., have been analyzed as to the most popular fare payment methods.

7.43.1 6 a.m. - 9 a.m. fare payment by frequency-of-use

The most popular fare payment methods of 1-2 trip per week users, illustrated in Figure 25, have been:

1. Adult Cash
2. Adult Pass
3. Elementary / Jr. High Week Pass

The most popular fare payment methods of 3-7 trip per week users, illustrated in Figure 26, have been:

1. Adult Cash
2. Adult Pass
3. Senior High Week Pass

The most popular fare payment methods of 8-10 trip per week users, illustrated in Figure 27, have been:

1. Adult Pass
2. Adult Cash
3. Elementary / Jr. High Week Pass

The most popular fare payment methods of 11+ trip per week users, illustrated in Figure 28, have been:

1. Adult Pass
2. Elementary / Jr. High Week Pass
3. Senior High Week Pass

The larger number of Adult Cash users than Adult Pass users for the 1-2 and 3-7 trip-per-week segments are perhaps indicative of users who work part-time or receive car-rides home from work. The Adult Pass users in the 1-2 trip per week segment are likely more frequent users who were surveyed during a non-typical week or may be infrequent users who have borrowed the pass from more frequent users. Beyond 8 trips per week, use of the Adult Pass dominates as expected. As seen previously in the post secondary user analysis, use of Adult Cash for the heavy and very heavy users is greater than Adult Ticket use, reinforcing the lack of perceived benefits from the Adult Ticket.

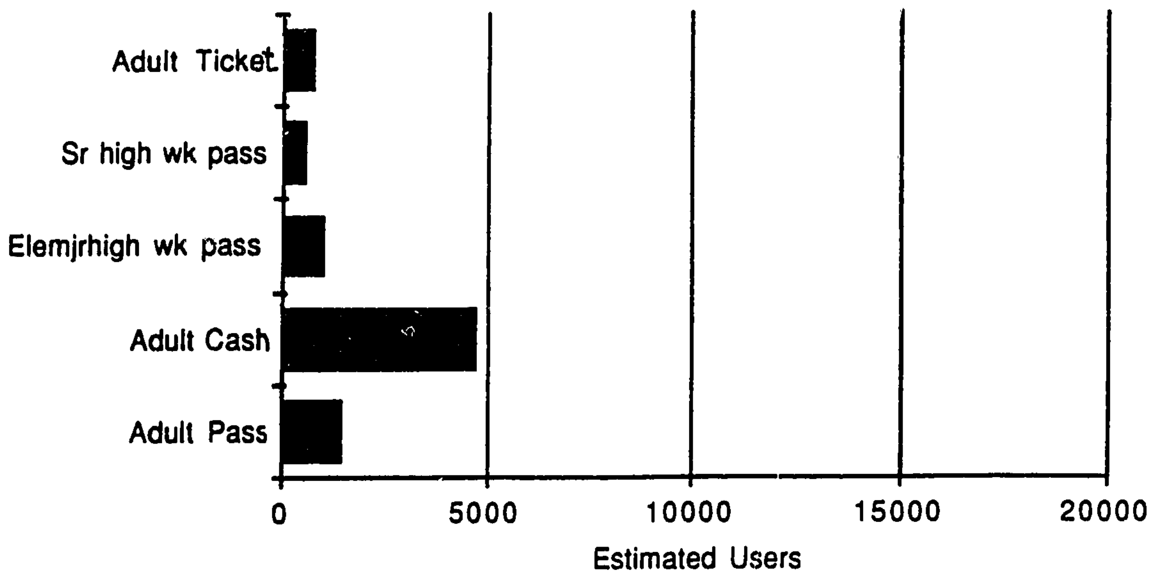


Figure 25. Fare Distribution, 6 a.m. - 9 a.m., 1-2 trips/week

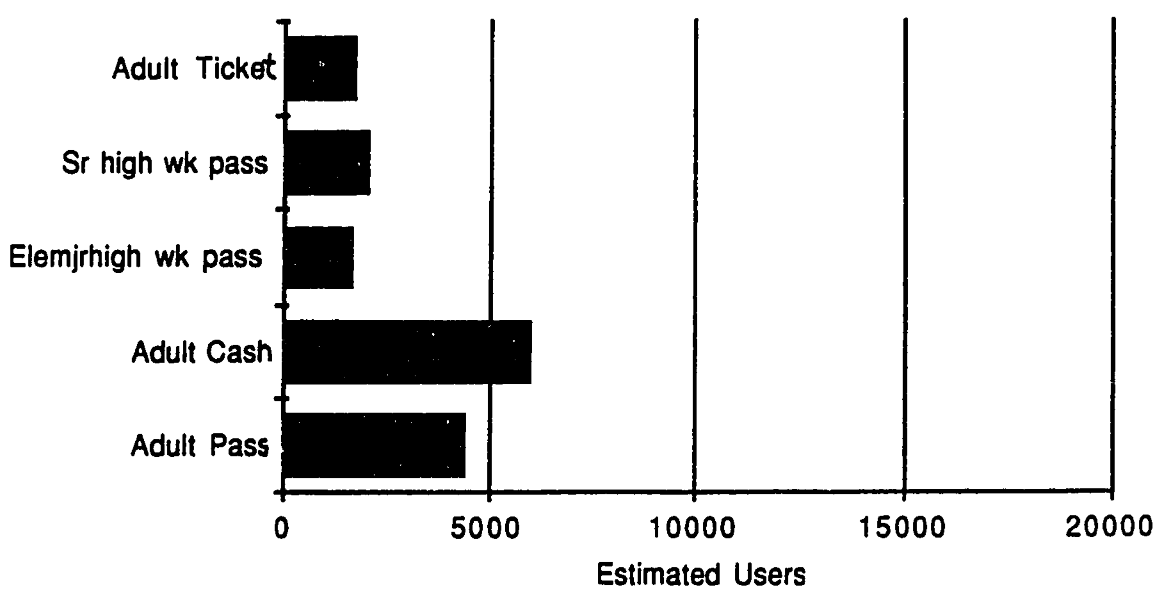


Figure 26. Fare Distribution, 6 a.m. - 9 a.m., 3-7 trips/week

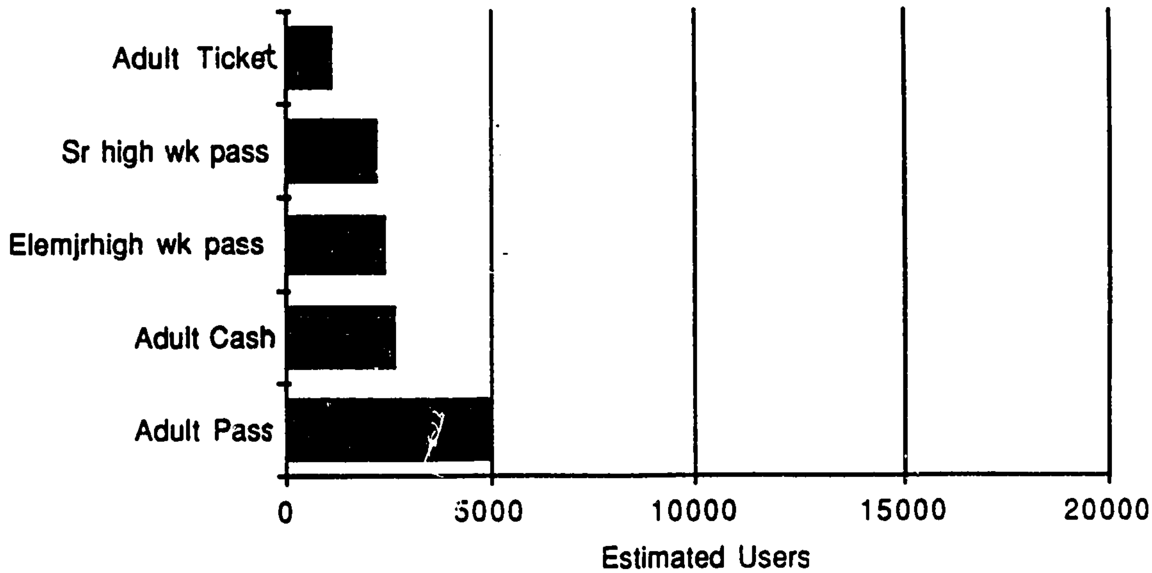


Figure 27. Fare Distribution, 6 a.m. - 9 a.m., 8-10 trips/week

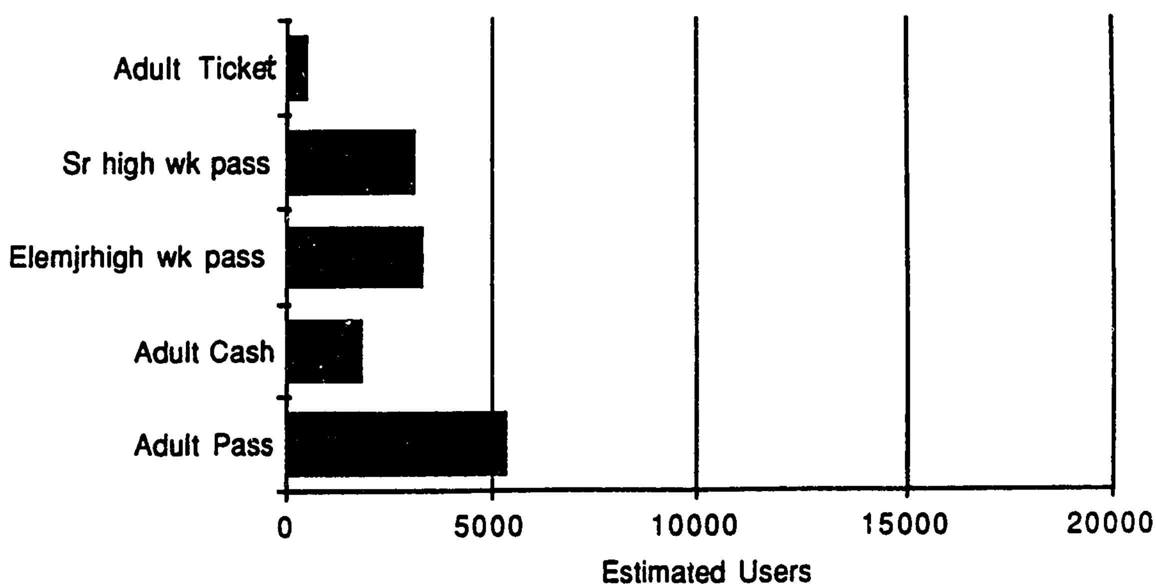


Figure 28. Fare Distribution, 6 a.m. - 9 a.m., 11+ trips/week

7.43.2 9 a.m. - 3 p.m. fare payment by frequency-of-use

The most popular fare payment methods of 1-2 trip per week users, illustrated in Figure 29, have been:

1. Adult Cash
2. Senior Annual Pass
3. Adult Ticket

The most popular fare payment methods of 3-7 trip per week users, illustrated in Figure 30, have been:

1. Adult Cash
2. Adult Pass
3. Senior.Annual Pass

The most popular fare payment methods of 8-10 trip per week users, illustrated in Figure 31, have been:

1. Adult Pass
2. Adult Cash
3. Senior High Week Pass

The most popular fare payment methods of 11+ trip per week users, illustrated in Figure 32, have been:

1. Adult Pass
2. Adult Cash
3. Senior High Week Pass

The majority of users for this time period reside in the 1-2 and 3-7 trip-per-week segments. Additionally, the preferred payment method of these users is Adult Cash. These users likely consist both of part-time workers who start during this time period, and people travelling to shop or take care of personal business.

A large segment of Senior Annual Pass users also exists during this time period. In fact, the segment is probably larger than indicated by the survey because the number of users in this segment was expected to be underestimated because of the routes surveyed (and actually was, as shown later).

The lack of heavy and very heavy users during this time period confirms that the majority of these type of users were surveyed travelling to and from work or school during the morning and evening peak periods. The favorite payment method of these segments during the afternoon off-peak period was the adult pass, as expected.

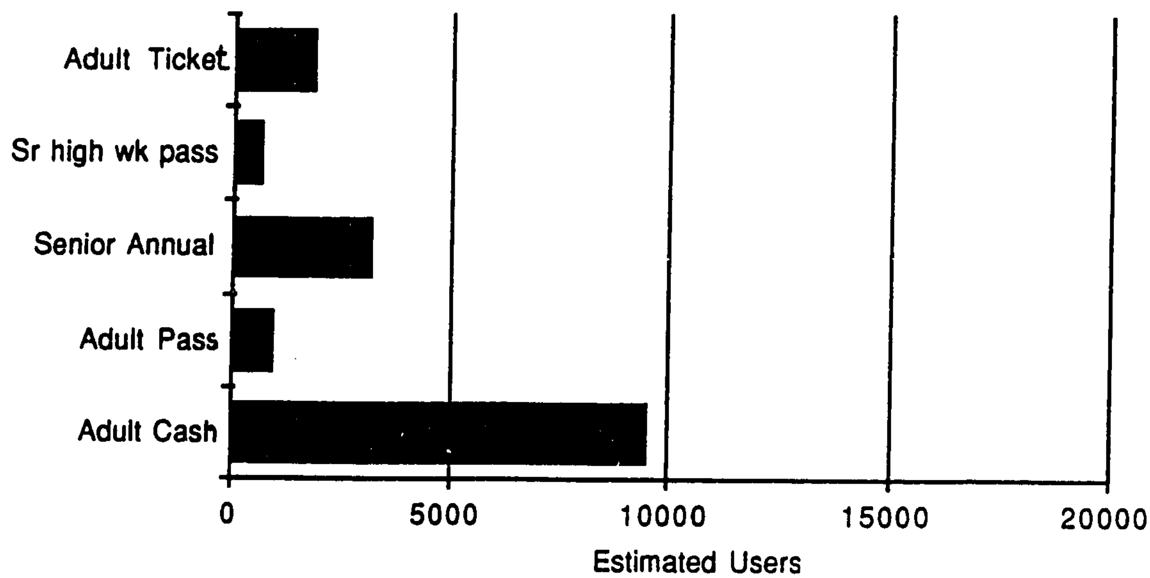


Figure 29. Fare Distribution, 9 a.m. - 3 p.m., 1-2 trips/week

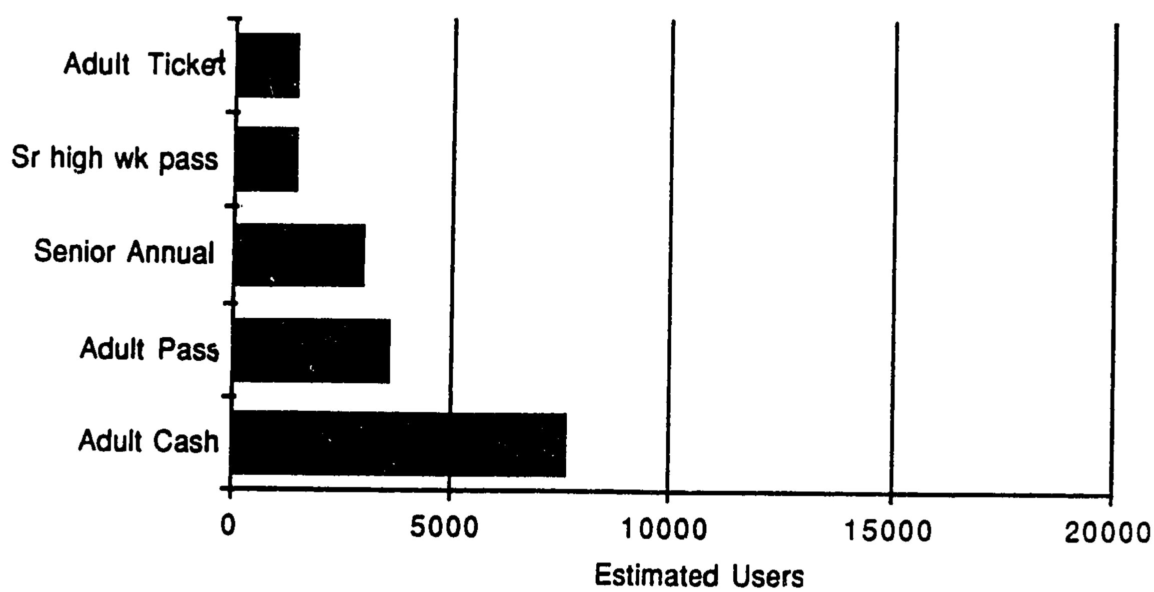


Figure 30. Fare Distribution, 9 a.m. - 3 p.m., 3-7 trips/week

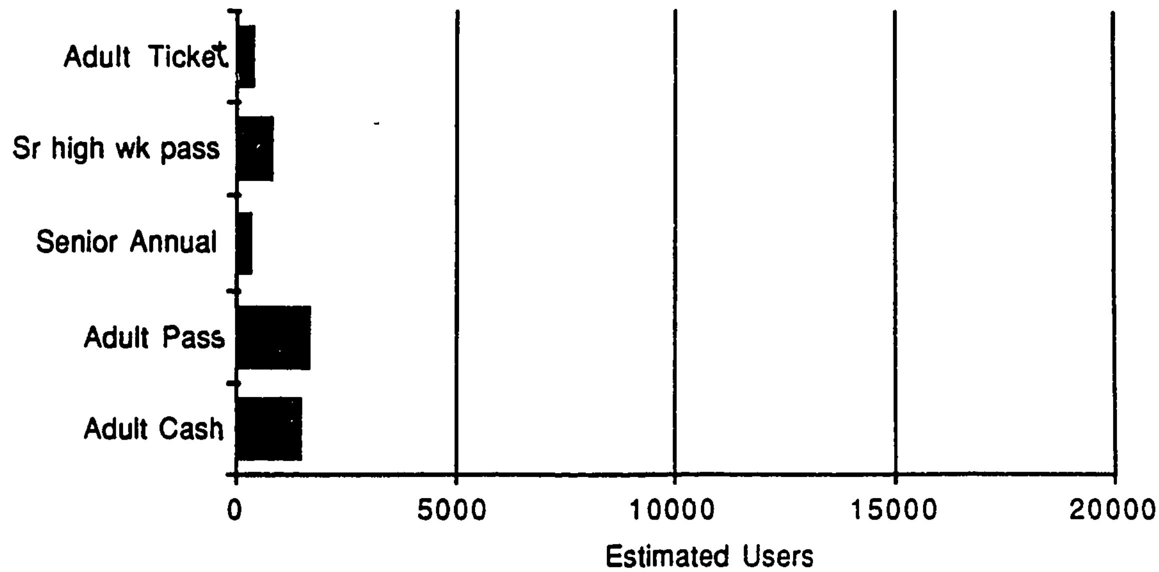


Figure 31. Fare Distribution, 9 a.m. - 3 p.m., 8-10 trips/week

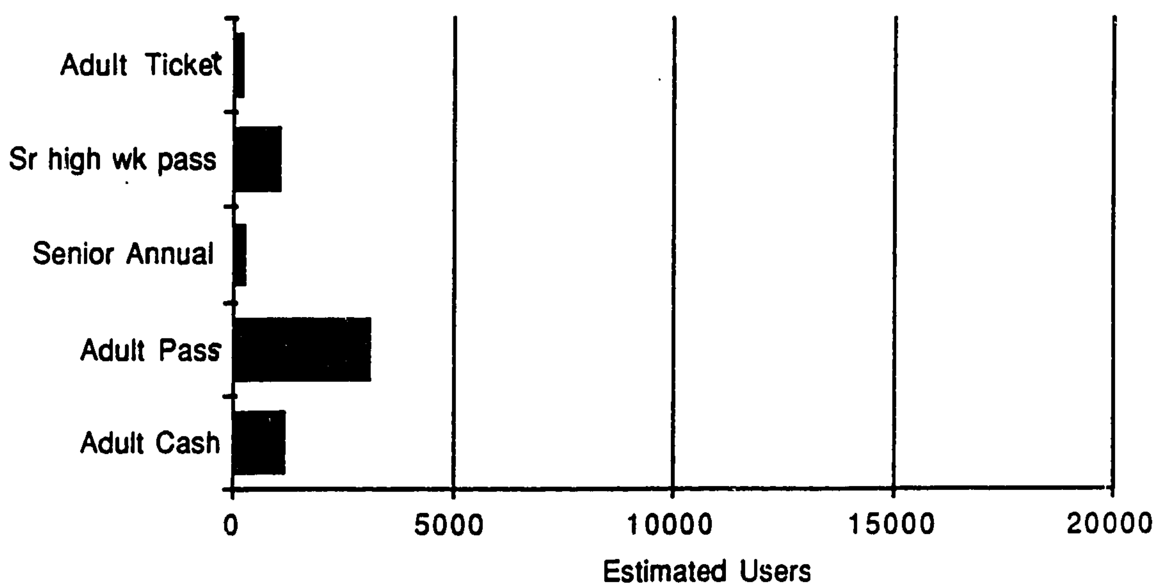


Figure 32. Fare Distribution, 9 a.m. - 3 p.m., 11+ trips/week

7.43.3 3 p.m. - 6 p.m. fare payment by frequency-of-use

The most popular fare payment methods of 1-2 trip per week users, illustrated in Figure 33, have been:

1. Adult Cash
2. Adult Ticket
3. Adult Pass

The most popular fare payment methods of 3-7 trip per week users, illustrated in Figure 34, have been:

1. Adult Cash
2. Adult Pass
3. Elementary / Jr. High Week Pass

The most popular fare payment methods of 8-10 trip per week users, illustrated in Figure 35, have been:

1. Adult Pass
2. Adult Cash
3. Elementary / Jr. High Week Pass

The most popular fare payment methods of 11+ trip per week users, illustrated in Figure 36, have been:

1. Adult Pass
2. Elementary / Jr. High Week Pass
3. Senior High Week Pass

The infrequent user segment is dominated by Adult Cash payment users, probably completing a journey which featured the trip to the destination being made during the 9am-3pm time period.

The heavy and very-heavy user segments favour the Adult Pass, as expected. In fact the number of Adult Pass users in each segment is nearly identical to those identified in the a.m. peak analysis, further validating the nature of the trip, ie. work or school.

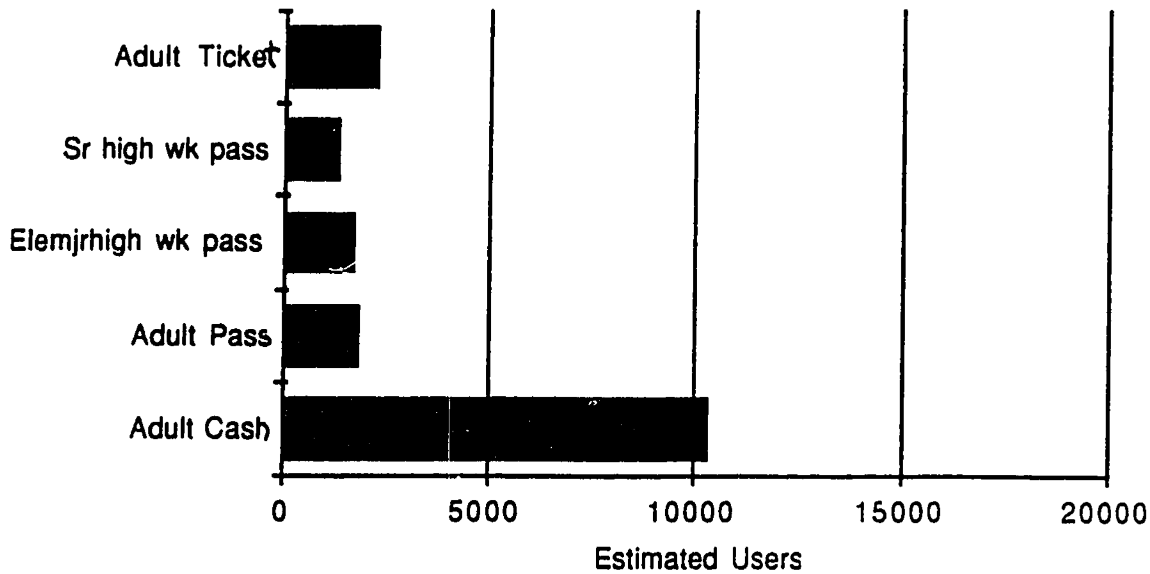


Figure 33. Fare Distribution, 3 p.m. - 6 p.m., 1-2 trips/week

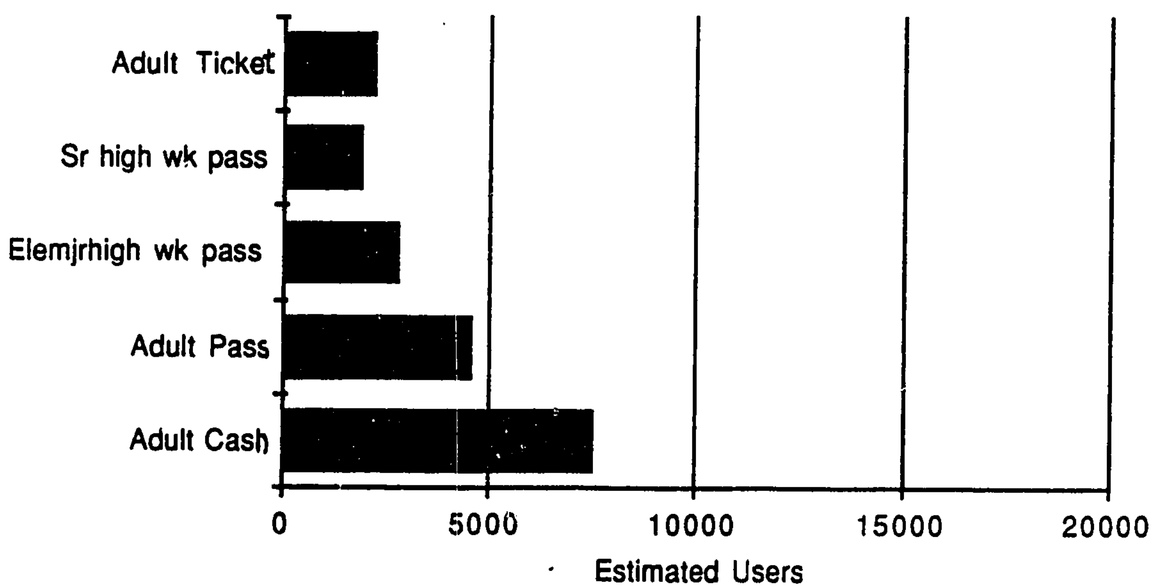


Figure 34. Fare Distribution, 3 p.m. - 6 p.m., 3-7 trips/week

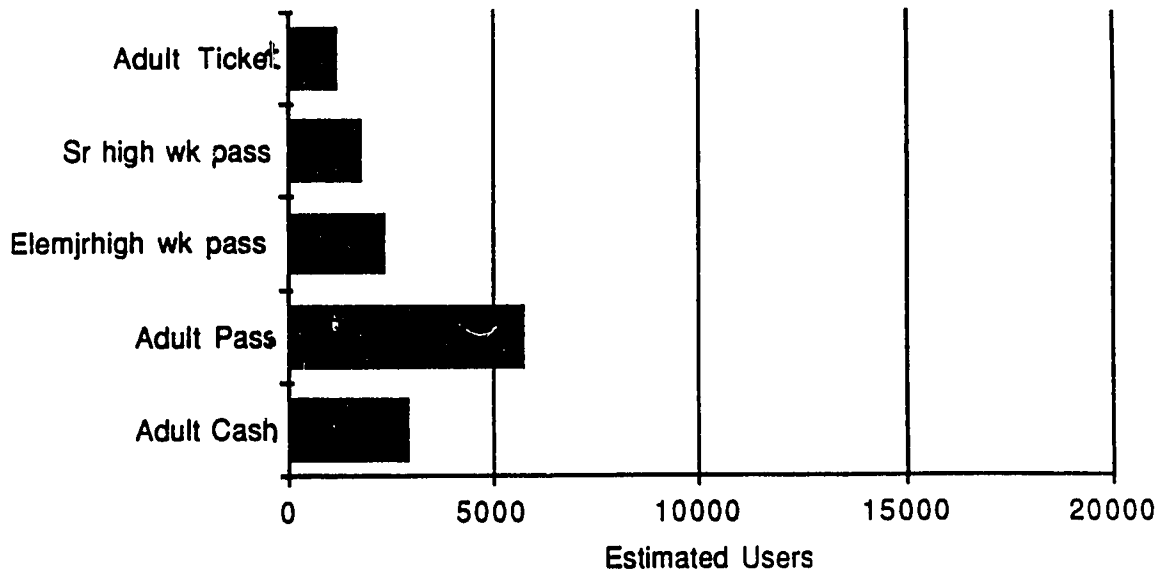


Figure 35. Fare Distribution, 3 p.m. - 6 p.m., 8-10 trips/week

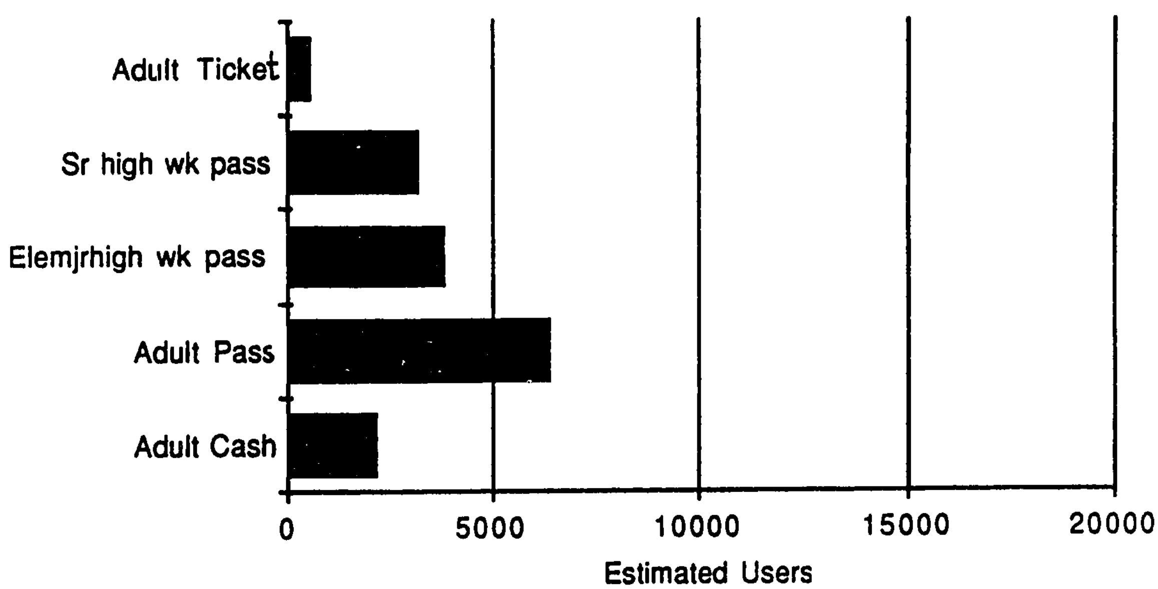


Figure 36. Fare Distribution, 3 p.m. - 6 p.m., 11+ trips/week

7.43.4 6 p.m. - 9:30 p.m. fare payment by frequency-of-use

The most popular fare payment methods of 1-2 trip per week users, illustrated in Figure 37, have been:

1. Adult Cash
2. Child Cash
3. Adult Pass

The most popular fare payment methods of 3-7 trip per week users, illustrated in Figure 38, have been:

1. Adult Cash
2. Adult Pass
3. Adult Ticket

The most popular fare payment methods of 8-10 trip per week users, illustrated in Figure 39, have been:

1. Adult Pass
2. Adult Cash
3. Adult Ticket

The most popular fare payment methods of 11+ trip per week users, illustrated in Figure 40, have been:

1. Adult Pass
2. Adult Cash
3. Elementary / Jr. High Week Pass

The majority of users in this time period are very light users (1-2 trips/week). The large segment paying by Adult Cash perhaps receive a ride to and from work each day but must rely on transit for travel in time periods beyond the pm peak period.

The very heavy user segment is dominated by Adult Pass users. These are likely users who were surveyed not only during the morning and evening peak periods, but also during the evening off-peak. These users are likely transit captives due to financial contraints. A typical segment of such users is examined later in this analysis.

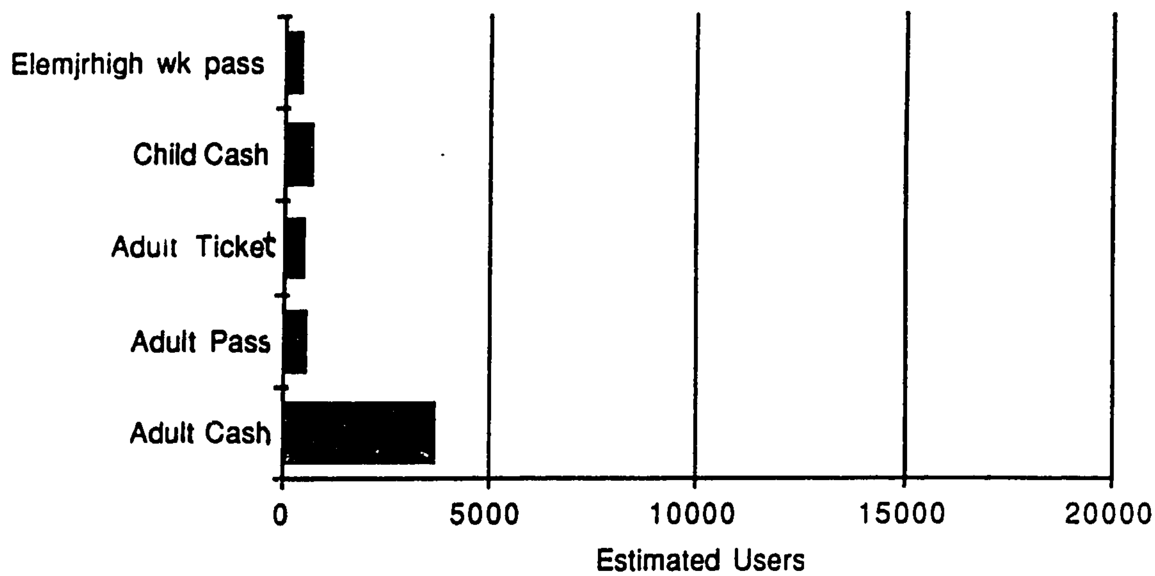


Figure 37. Fare Distribution, 6 p.m. - 9:30 p.m., 1-2 trips/week

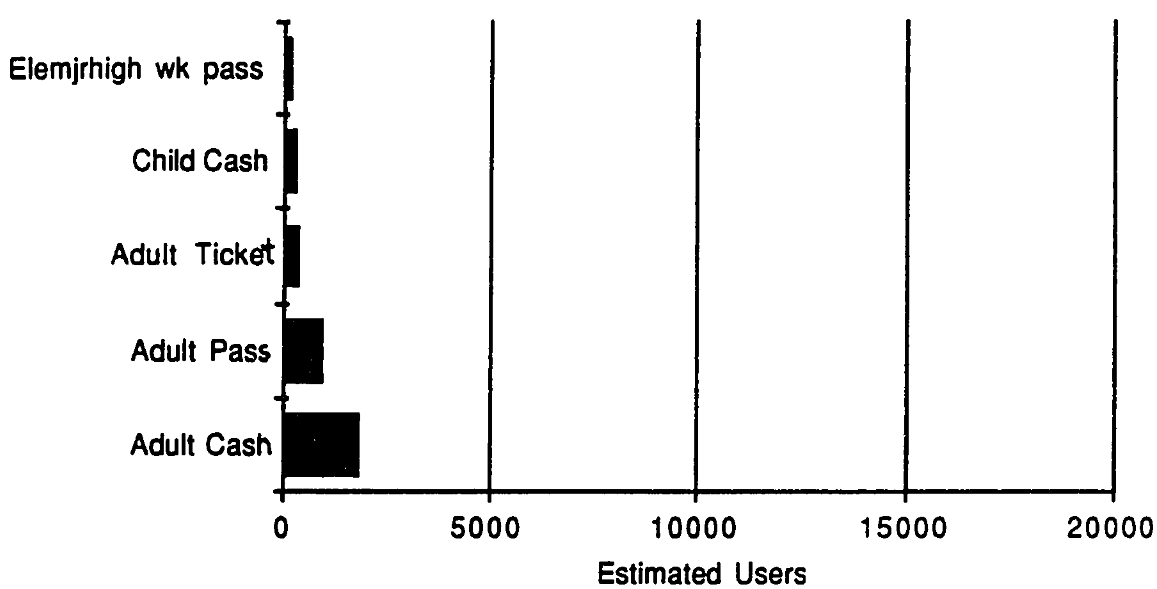


Figure 38. Fare Distribution, 6 p.m. - 9:30 p.m., 3-7 trips/week

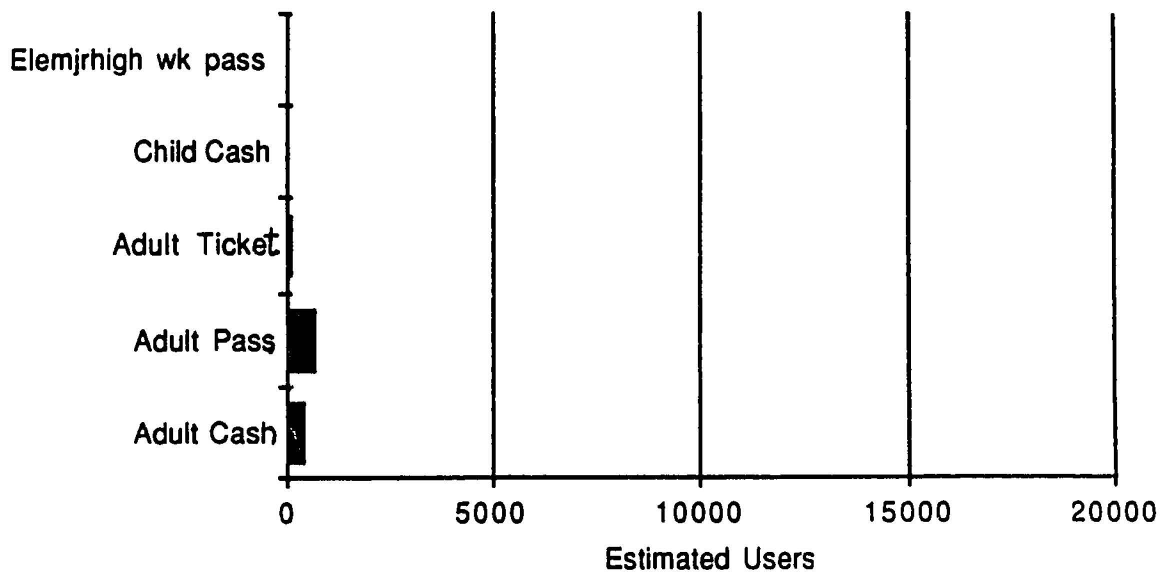


Figure 39. Fare Distribution, 6 p.m. - 9:30 p.m., 8-10 trips/week

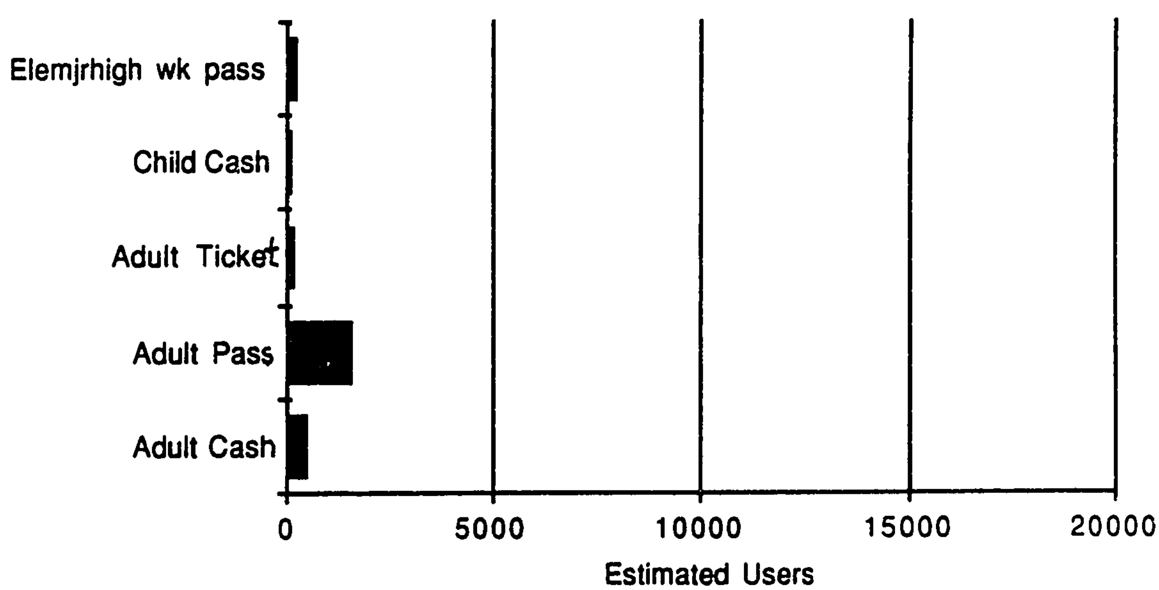


Figure 40. Fare Distribution, 6 p.m. - 9:30 p.m., 11+ trips/week

On a slightly more aggregated level, the number of Adult Pass users has been greater than number of Adult Cash users only in the 6 a.m. - 9 a.m. period. Overall, Adult Cash has been the most used fare payment method, and predominantly by a large segment of light to medium frequency users.

7.44 Specific Examples of Segment Analysis

Various other characteristics have been examined to illustrate the uses of the Transit User Estimation Model. The following characteristics have been analyzed:

1. Overall fare payment distribution of non-cash users.
2. Users age distribution for weekly frequency of use categories.
3. Users age distribution for a specific destination purpose between 9 a.m. and 3 p.m.
4. Users weekly frequency of use distribution for a specific destination purpose between 6 p.m. and 9:30 p.m.
5. Users weekly frequency of use distributions of various fare payment methods for 6am-9am work trips.

7.45 Fare Payment Distribution of Non-Cash Users

The fare payment methods of non-cash users have been estimated with the model of Chapter 6. Direct comparison of the estimates with actual sales (November 1987) can be made for all forms of passes and tickets if it is assumed that a negligible number of pass or ticket users use transit on the weekends only (the model is based on weekday data).

The results of the comparison, shown in Table 14, have been further evidence of the validity of the model. The only major discrepancy occurs for Senior Annual Pass sales. Assuming that the majority of 65+ year-old users utilize the this method of payment, the model error can be explained in that Edmonton Transit has expected this underestimation due to the areas surveyed.

Final model non-cash fare payment estimates vs actual sales in November 1987:

Payment method	Estimated	Actual
ElemJrHigh weekday pass	13,569	11,021
Sr High weekday pass	13,606	8,626
Sr.High Adult monthly	4,585	3,869
Student Pak	4,442	3,630
Adult Monthly pass	31,776	23,485
Senior Annual pass	9,361	24,102
Other pass	1,605	1,314

Table 14. Comparison of Final Model Estimates with actual sales from November 1987

7.46 Age Distribution of Users for Weekly Frequencies of Use

The age distribution of users for the weekly frequencies of use is shown in Figure 41.

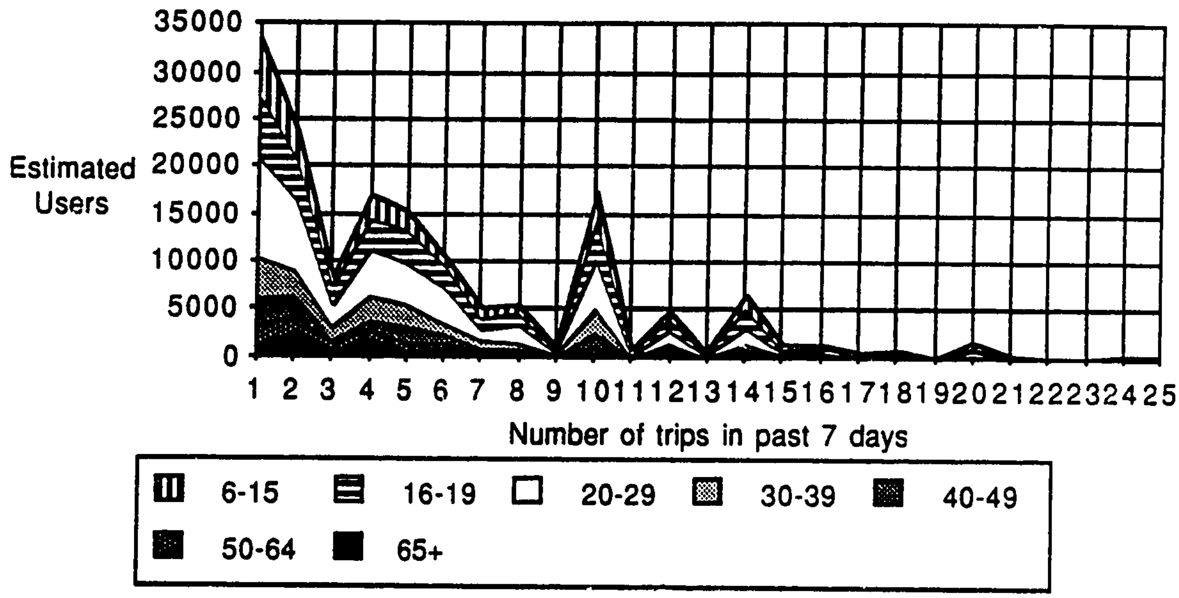


Figure 41. User age distribution

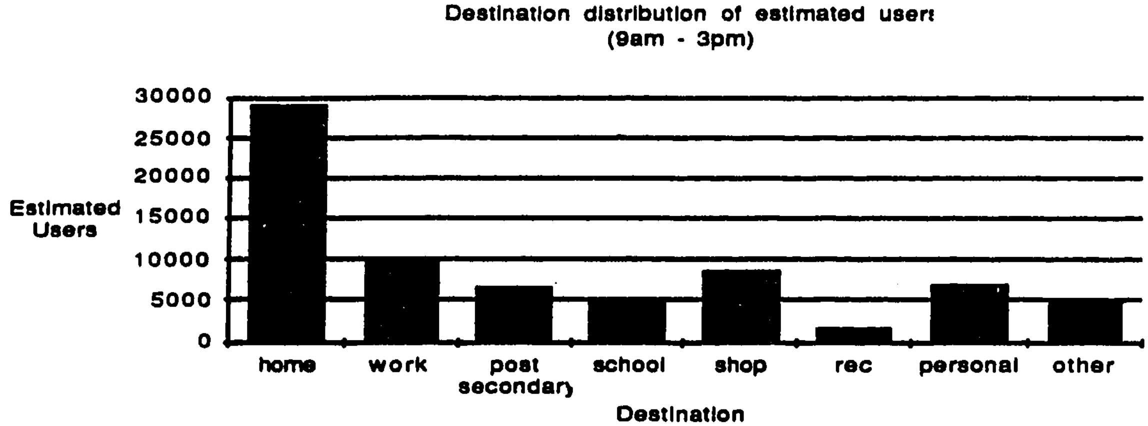
This graph shows that 20-29 year-olds form the largest user segment, although the 16-19 year-old segment is nearly as large, and has a smaller age range. These segments are indicative of high activity groups without the financial resource to own or operate a car.

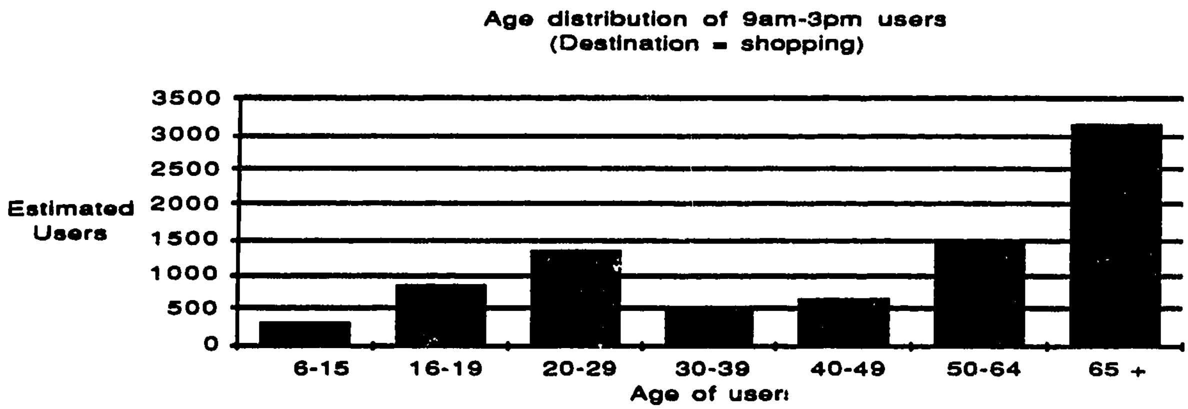
Peaks occur at 12 and 14 trips per week. These trips likely consist of 10 work trips, and 2 or 4 trips made respectively for once or twice weekly activities.

50-64 and 65+ year-old age groups are predominantly infrequent users. This result agrees with the previous analyis of users for the various time periods

7.47 Afternoon Off-Peak Period Example (9 a.m. - 3 p.m.)

A specific segment, based on time of travel, destination purpose, age, and weekly frequency of use, is illustrated in Figure 42. Specifically, the weekly frequency of use distribution of 65+ year-old users who are shopping between 9 a.m. and 3 p.m. is developed.





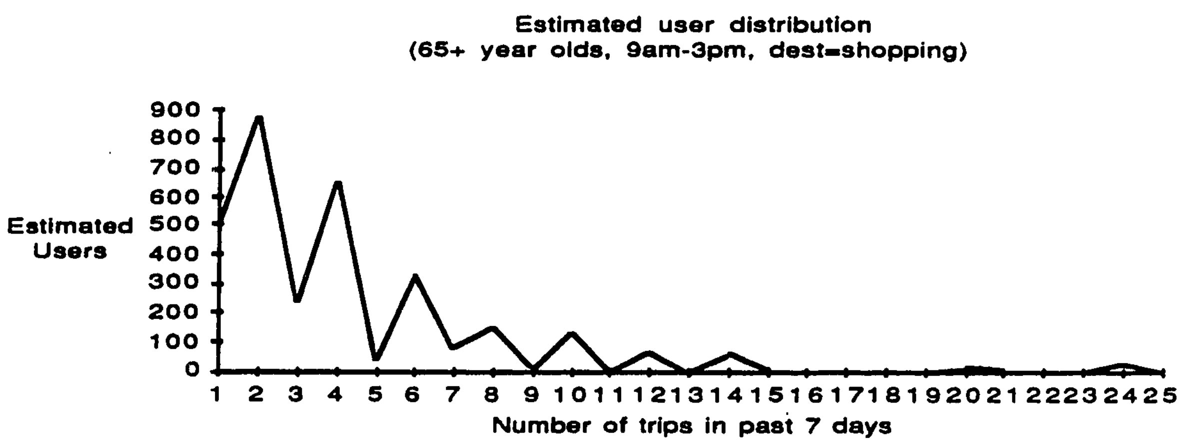


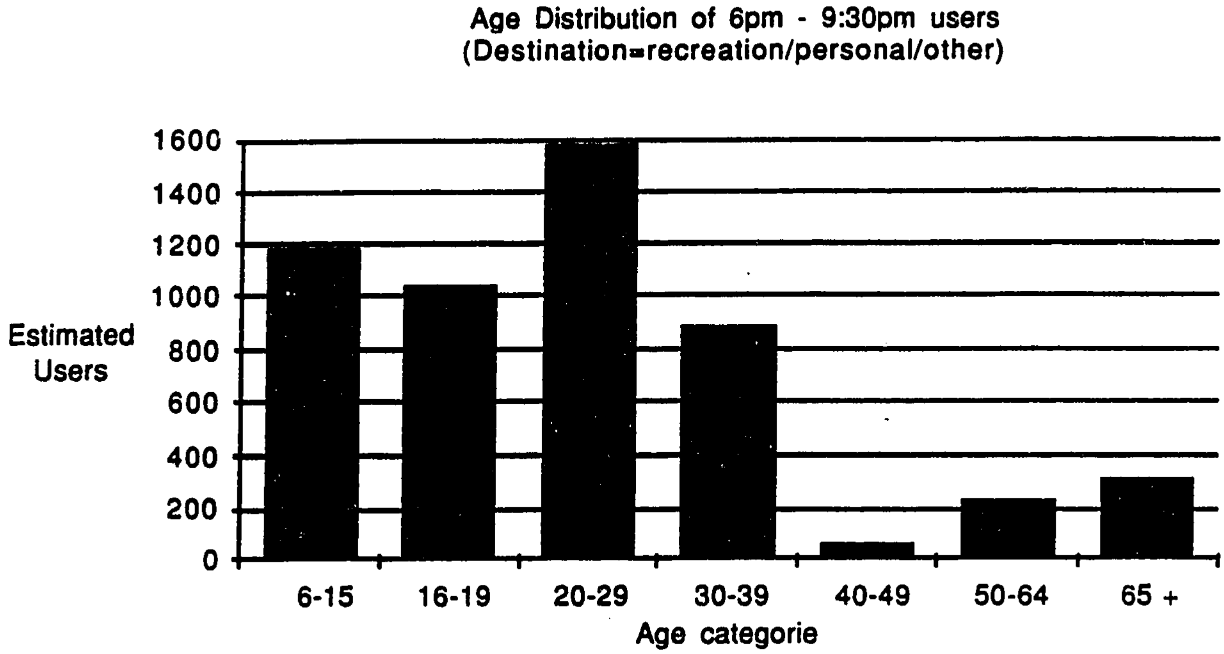
Figure 42. Afternoon off-peak period segment example

If work-destination trips are removed, the number of non-work-destination trips is approximately the same as the number of home-destination trips. This indicates that two trips are being made in this time period.

65+ and 50-64 year-olds form the largest segments, possibly for the purpose of socializing, light grocery shopping, lunch, at shopping centres.

7.48 Evening Off-Peak Period Example (6 p.m. - 9:30 p.m.)

A specific segment, based on time of travel, age, and weekly frequency of use, is developed in Figure 43. Specifically, the weekly frequency of use distribution for 20-29 year-old users, travelling between 6 p.m. and 9:30 p.m., is examined.



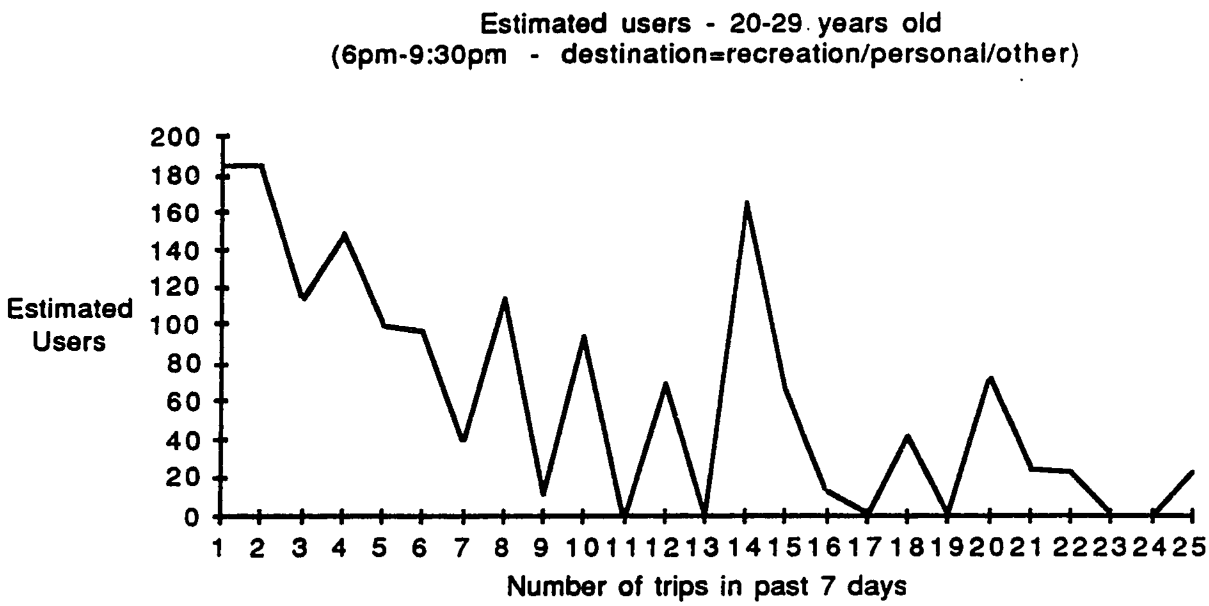


Figure 43. Evening off-peak segment example

This development shows that 6-15, 16-19, 20-29 year-old users form the largest segments for this time period. These are high activity groups without the financial resources to own or operate a car, therefore the reliance on public transit.

The 20-29 year-old users have pronounced peaks at 12, 14, 18, and 20 trips per week, indicating that they use transit heavily for non-work purposes, in addition to work trips. The distribution likely consists of 5 trips to and 5 trips from work per week, plus different activity event travel occurring once, twice, four and five times a week.

7.49 Work Trip Fare Payment Example (6 a.m. - 9 a.m.)

A specific segment, based on time of travel, destination purpose, and weekly frequency of use, is illustrated in Figure 44.

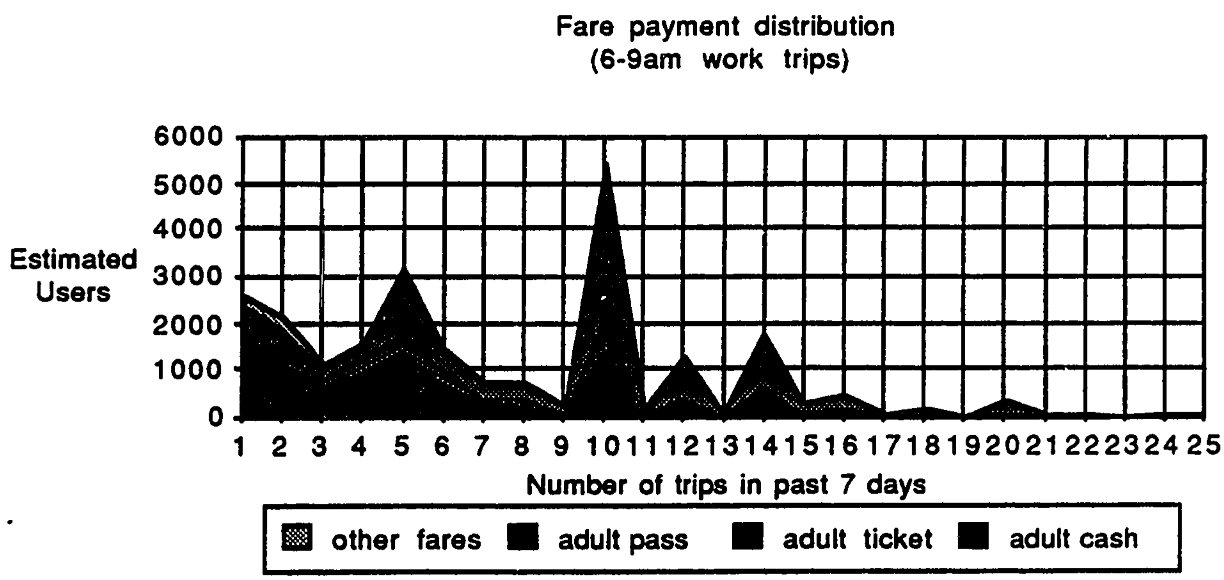


Figure 44. Work trip fare payment example

Specifically, the weekly frequency of use distribution, for various fare payment methods, of users travelling to work between 6 a.m. and 9 a.m., are examined. This illustration shows that the large segment paying by Adult Cash are predominantly infrequent users. These users may receive a car-ride home at days end, or possibly are part-time workers.

The infrequent-use pass users are perhaps heavy users surveyed during a non-typical week. These users may also have borrowed a pass from a heavy user.

Adult Pass use dominates beyond 10 trips per week as expected.

7.5 Application of the Transit User Estimation Model

The Transit Ridership Analysis research is one aspect of an overall new approach to marketing which Edmonton Transit decided to pursue in 1989. This research has provided a tool which Edmonton Transit can use for analyzing various market segments.

The post-secondary user segment was analyzed in this research and the results have already been applied by Edmonton Transit. This research identified that approximately 6000 users of that segment were utilizing the Adult Pass, but only around 3500 users were utilizing the Student Pak.

In an effort to increase use of the Student Pak, Edmonton transit altered the price so that purchase of this item would result in a 10% saving to the user over the Adult Pass.

This change has resulted in an increase in Student Pak sales and a reduction in Adult Pass sales. The change is not an even trade in that the increase in Student Pak sales appears to be larger than the reduction in Adult Pass sales. Increased use of passes is one of the objectives of Edmonton Transit so the model has already been useful.

8.0 CONCLUSIONS

The Transit User Analysis has consisted basically of two stages. The first stage has involved the development, verification, and calibration of a transit user estimation model which could transform passenger data into user data. In the second stage the model has been used to analyze various user segments of Edmonton Transit passengers. Because of these distinct stages in the study, the conclusions which have resulted from each are separated in this Chapter.

8.1 Transit User Estimation Model

Based on the development, verification, and calibration of the Transit User Estimation Model in this study, the following conclusions may be made:

1. The main objective of the research has been satisfied, i.e., to identify the characteristics of the people who use public transit in Edmonton, on both aggregate and disaggregate levels, using the 1988/89 Fare Survey data in conjunction with other available Edmonton travel information. The following are the transit user characteristics which have or can be identified as a result of this research:

   a. Total number.
   b. Distribution within weekly frequency-of-use classes.
   c. Disaggregated fare payment methods.
   d. Distribution of use during different time periods.
   e. Age distribution.
   f. Origin and Destination distributions.
   g. Combinations of characteristics a - f.

2. The basic assumptions on which the model is based, listed in Section 3.1, are valid.

3. The analysis of passengers differs from the analysis of users because of the undercounting and overcounting sample bias associated with light and very-heavy transit users.

4. The route-extrapolation model is a reasonable alternative to the passenger-extrapolation model when operator counts are unavailable.

5. The 1988/89 Fare Survey provides a good basis for analysis of transit user characteristics in Edmonton.

6. Future surveys should use a different method of coding non-responses to questions, such as negative number.

7. The model developed in this study is valid for prediction of transit user characteristics. It has been validated through comparison of its estimates of total users, total ridership, weekly frequency-of-use distribution, and non-cash fare payment distribution with other available transit data.

8. When analyzing specific segments, one of the variations of the model, described in Section 6.2, may be more appropriate for use than the full-day model.

9. Future passenger surveys should include a question on weekly frequency of use, so that the model of this study may be used to convert the passenger data into user data. As well, other surveys should be conducted at that point in time so that data is available for verification and calibration.

10. The two-trip scenario version of the passenger-extrapolation model has been judged the best estimator of total users, total ridership, weekly frequency-of-use distribution, and non-cash fare payment distributions.

8.2 Results of User Analysis

Based on the results of the the user segmentation analysis, the following conclusions may be made:

1. Approximately 200,000 people use transit in Edmonton.

2. The weekly frequency-of-use distribution of these users is approximately the following:

1-2 trips/week:	36%
3-7 trips/week:	36%
8-10 trips/week:	15%
11+ trips/week:	13%

3. Some of the fare payment methods of users, within different time periods, changed significantly between the 1988 and 1989 portions of the Fare Survey. The fare payment methods which changed significantly, using a 5% probability of error, within each time period are:

a) 6 a.m. - 9 a.m.: Adult Cash
Child Cash
Adult Ticket

b) 9 a.m. - 3 p.m.: | Adult Cash
Adult Ticket
Student Pak
Adult Monthly Pass
Senior Annual Pass
Non-cash fares in aggregate

c) 3 p.m. - 6 p.m.: | Adult Cash
Child Cash
Adult Ticket
Senior Annual Pass
Non-cash fares in aggregate

d) 6 p.m. - 9:30 p.m.: | Child Cash
Child Ticket
Adult Monthly Pass
Non-cash fares in aggregate

4. Adult Cash is the most popular fare payment method used overall. It is the predominant method used by light to medium frequency users.

5. There are approximately 17,000 post-secondary destination transit users. Approximately 20% of these users use the student pak.

6. The 16-19 and 20-29 year-old age categories contain the largest segments of users, indicative of of high activity groups without the financial resources to own or operate a car.

7. 50-64 and 65+ year-old users are predominantly light users, and travel mainly between 9am and 3pm.

8. For the morning-peak work trip, a large segment of light-use cash payment users exists. The heavy use segment in this time period consists predominantly of Adult Monthly Pass users, as expected.

9. Use of the model beyond three levels of segmentation may result in statistically unreliable results.

9.0 REFERENCES

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